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Investigations on the Biology and Control of Timothy Grass Flies Amaurosoma armillatum Zett. and A. flavipes Fall. (Dipt. Cordyluridæ)

Undersökningar över timotejflugornas
(Amaurosoma armillatum Zett. och *A. flavipes* Fall.;
DIPT. Cordyluridæ) biologi och bekämpning

BY
ÅKE BORG

Med svensk sammanfattning

With 33 Figures and 12 Tables

STOCKHOLM 1959

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Emil Kihlströms Tryckeri AB Stockholm 1959

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Introduction

In seed crops of Timothy grass in Sweden, one of the most common pests is the larvae of Timothy grass flies. Some years, the damage, which is easily proved and very characteristic, is of small economic importance, but other years it may be very serious; this is on account of the natural fluctuation in numbers which always occurs among insects. Since Timothy grass flies are common pests, which have not before been investigated thoroughly in Sweden, and furthermore pests for which no effective control measures were known, investigations on Timothy flies were put on the program of the Swedish Plant Protection Institute. The investigations were carried out during the years 1950—56 at the Branch Station of the Institute at Skara, Västergötland.

I. Synonyms. Reported species of Timothy grass flies

Among flies denominated Timothy grass flies literature mentions *Amaurosoma armillatum* Zett. and *A. flavipes* Fall. appearing in a number of European countries and further a related species *Trichopalpus* (*Chaetosa*) *punctipes* Meig. in inter alia France.

A. armillatum was described by ZETTERSTEDT in 1846 as *Cordylura armillata*. The species was placed by BECKER (1894) in his new genus *Amaurosoma*.

A. flavipes was described in 1819 by FALLÉN as *Cordylura flavipes* and this name was used by ZETTERSTEDT. SCHINER (1864) called the species *Cleigastra flavipes* and BECKER made *flavipes* the type of the genus *Amaurosoma*. According to BECKER, *Cordylura frontalis* Macq. and according to SÉGUY (1934) *Cnemopogon flavipes* (var. 1) Pandellé are further synonyms of *A. flavipes* Fall. However, this species is not identical with the one which MEIGEN (1826) named *Cordylura flavipes*; this was already stated by ZETTERSTEDT. *Cordylura flavipes* Meig. now has the name *Trichopalpus* (*Chaetosa*) *punctipes* Meig.

The above mentioned authors only deal with systematic characters and do not enter into the biology of the flies. The first one to prove that the larvae of *A. armillatum* are pests on Timothy grass ears, was LAMPA (1893), who reared larvae of this species collected at Östra Karup just to the North

of the Hallandsås in Sweden. Some years later, REUTER (1900) proved the same in Finland. Regarding the other species, earlier statements are rather dubious since distinction between *flavipes* Fall. and *flavipes* Meig. has not always been made, which fact was put forth by WAHL (1943). The report that *flavipes* Meig. (=*Trichopalpus punctipes* Meig.) has the Timothy grass as its host plant originates from NOWICKI (1874), who calls the insect *Cleigastra flavipes* Meig. This species was later connected with attacks on Timothy e. g. by LAMPA (1892), who, however, had then seen the larvae only. Later LAMPA (1901) found that attacks on Timothy in Sweden were caused by *flavipes* Fall. as well as by *armillatum* as already mentioned. In Finland, REUTER had already pointed out that these two species (*flavipes* Fall. and *armillatum*) are pests of Timothy grass.

LINDEMAN (1887), in his Russian paper mentions *T. punctipes* Meig. as a pest of Timothy grass. He was also the first person to investigate the biology of Timothy flies more closely. LINDEMAN, however, used the older denomination *Cleigastra flavipes* Meig. From his description of the full grown fly, the following important characteristics must be cited: "Die *erwachsene Fliege* ist ca. 5 Mm. gross. Schwarz, dicht grau bereift. Schenkel an der Spitze, Schienen und die Wurzeln der Füsse gelbbraun. Fühler schwarz" (p. 204); "Von der *Cleigastra flavipes* Fall. wie sie bei SCHINER, Fauna Austriaca. II. p. 11, beschrieben, unterscheiden sich die von mir aus Larven gezogenen Fliegen nur durch die in der Mitte dunkelgefärbten Schenkel; im Uebrigen entsprechen sie ganz der Beschreibung bei SCHINER" (p. 205). The quotation shows plainly that the species investigated by LINDEMAN is not *Cleigastra flavipes* Meig. or, as it is now called, *T. punctipes* Meig. for the legs of the latter species as well as all the femorae (= German "Schenkel") are yellow. Further, the antennae of *T. punctipes* are not black, but, a brownish colour on the females, and yellow on the males. The species described and investigated by LINDEMAN may possibly be *armillatum*. KARPOVA (1930) has later shown that both *flavipes* Fall. and *armillatum* Zett. appear as pests of Timothy seed in Russia.

According to what the writer has been able to find from investigations on Timothy flies carried out during this century, it has not yet been proved that *Trichopalpus punctipes* Meig.. has emerged from larvae collected on Timothy grass but only *armillatum* and *flavipes* Fall. (REUTER, LAMPA, KARPOVA, KING, MEIKLE and BROADFOOT 1935, BARNES 1935, WAHL, MÜHLE 1953 and BORG 1955). On the other hand, some other papers have stated that *T. punctipes* lives on Timothy grass. In their well known synopsis BALACHOWSKY and MESNIL (1935) have assigned only *T. punctipes* Meig. (*Cleigastra flavipes* Meig. nec Fall.) to France. *Armillatum* Zett. is also mentioned as occuring in Northern Europe, but they do not mention *flavipes* Fall. The sources which BALACHOWSKY and MESNIL quote to support the report that *T. punctipes* attacks Timothy are inter alia NOWICKI, TASCHENBERG and

LINDEMAN. However, NOWICKI's statement as to species is uncertain, as well as that of TASCHENBERG (besides the latter adds that he has taken the description from NOWICKI not having seen the imago of the fly himself). As already mentioned, LINDEMAN's statements do not apply to *T. punctipes*.[1]

In "Faune de France" SÉGUY (1934) also classifies *T. punctipes* as a pest of Timothy and further omits the information that *flavipes* Fall. appears on Timothy. As proved by WAHL, the same omission is made in SACK's paper on *Cordyluridae* (1937): *T. punctipes* is reported to live on Timothy and *flavipes* Fall. on *Euphorbia*. WAHL was not able to discover if SACK's statement that *Euphorbia* was the host plant was based on personal observations, but seems to believe that it applies to swarming flies only. However, even SÉGUY mentions *Euphorbia* for *flavipes* Fall. (but not Timothy) and refers to PANDELLÉ (1898—1902, p. 305). The latter, however, does not say anything about the biology of the flies. From the brief statements it can be clearly seen that PANDELLÉ has taken fully grown flies (*A. flavipes* Fall., or, according to PANDELLÉ, *Cnemopogon flavipes* Fall., var. 1) from *Euphorbia* in the months April—May at Tarbes in Southern France. To state as SÉGUY and SACK that *flavipes* Fall. occurs on *Euphorbia* must be considered misleading.

To sum up it may be said, that in the family *Cordyluridae* (*Scatophagidae*) only *A. flavipes* Fall. and *armillatum* Zett. up to now, have with certainty been proved to emerge from larvae collected on damaged ears of Timothy grass. However, it is not impossible, as pointed out by WAHL, that some other species of *Amaurosoma* may be proved to be pests of Timothy grass.

[1] Nor do the figures representing *T. punctipes* reproduced by BALACHOWSKY and MESNIL solve the question of wether this species or *flavipes* Fall. occurs in France on Timothy. The figures are in some respects more like *flavipes* Fall. than *punctipes*, e. g. the antennae and the palpi. The palpi have a slim outline according to the figure and no apical bristle. This corresponds with the build of the palpi on *flavipes* Fall., but not on *T. punctipes*.

II. A short description of *A. armillatum* and *flavipes*

The flies of the genus *Amaurosoma* are usually placed in the family *Cordyluridae* (=*Scatomyzidae, Scatophagidae, Scopeumatidae*). For closer systematic characteristics e. g. as to the number of bristles and their arrangement on the flies, as well as their position in the system, the writer refers to systematic papers, e. g. WAHLGREN (1917), SÉGUY, SACK and HACKMAN (1956).

The Timothy flies are about half a centimetre long. To the naked eye the flies appear dark grey or dark brown. They are smaller and more slender than e. g. the common house-fly. In favourable light one can distinguish the two species with the naked eye, particularly because of the colour of the legs, see below.

A. armillatum Zett.

Male and female. The head is relatively large and well rounded. The frons between the eyes is black in the centre, nearer the eyes greyish; above.

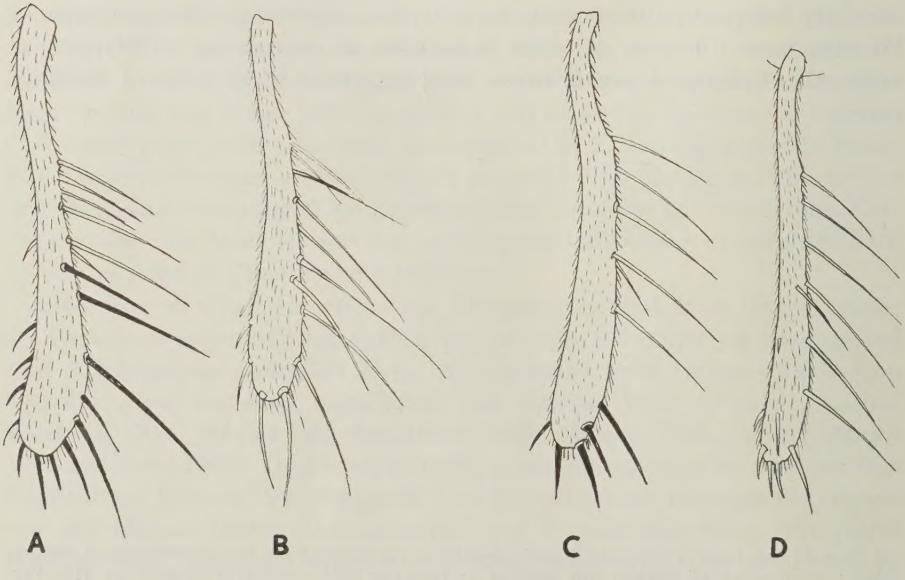

Fig. 1. Left maxillary palp: A and B of armillatum Zett. female and male respectively; C and D of flavipes Fall. female and male respectively.

Vänster palp: A och B av armillatum Zett. hona resp. hane; C och D av flavipes Fall. hona resp. hane.

Fig. 2. Left fore leg of armillatum Zett. ♀ (A) and of flavipes Fall. ♀ (B).
Vänster framben av armillatum Zett. ♀ (A) och av flavipes Fall. ♀ (B).

dorsal to the antennae, with a yellow-reddish macula. The face is white-yellowish. The eyes are large, round, shimmering in dark red and they are naked. The antennae are black; the upper apical corner of the third joint of the antenna is almost rectangular seen from the side while the lower apical corner is evenly rounded. The terminal joint has a dorsal arista which is black, thickening from the base to the centre. The maxillary palpi are yellow-whitish and without apical bristle (fig. 1). The proboscis is black.

The thorax and coxae are dark grey, the femorae are black from the base to below the centre (fig. 2), the rest yellow-brown; the lighter distal extremity of femorae may be considered a yellow- or red-brown band, hence the Swedish name "den gulringade timotejflugan" (the yellowringed Timothy grass fly); tibiae and tarsi are yellow-brown. The wings are somewhat hyaline with a light brown shade, but with a metallic sheen in some light. Squamae and halteres are light. The abdomen is dark grey. Seen from the side the end of abdomen of the female is conical; the abdomen of the male broadens at the caudal end.

Length of body: ten females measured from 4.5 to 5.3 mm. (average length 5.0 mm.) and ten males from 4.0 to 4.8 mm. (average length 4.5 mm.).

A. flavipes Fall.

Male and female. Head as on *armillatum.* Thorax dark grey. The fore coxae yellow-brown, central and hind pairs dark grey. Femorae yellow-brown, fore pair with a lengthy dark stripe on the upper side (fig. 2). Tibiae and tarsi yellow-brown, the latter darker. Wings, squamae and halteres as on *armillatum.* Abdomen as *armillatum* (fig. 3).

Lenght of body: ten females measured from 4.7 to 6.2 mm. (average length 5.3 mm.) and ten males from 3.7 to 4.8 mm. (average length 4.2 mm.).

According to Ringdahl (1952), nine species of *Amaurosoma* are known in Sweden. The biology, however, has only been described for *armillatum* and *flavipes. A. armillatum* may possibly be confused with *A. tibiellum* Zett. The femorae of the latter, however, are darker than those of *armillatum,* since only the exterior point is yellow-brown, whereas the circular,

Fig. 3. Amaurosoma flavipes Fall., female (lenght about 5—6 mm in natural size).

Hona av Amaurosoma flavipes Fall. Kroppslängd ca 5—6 mm i naturlig storlek.

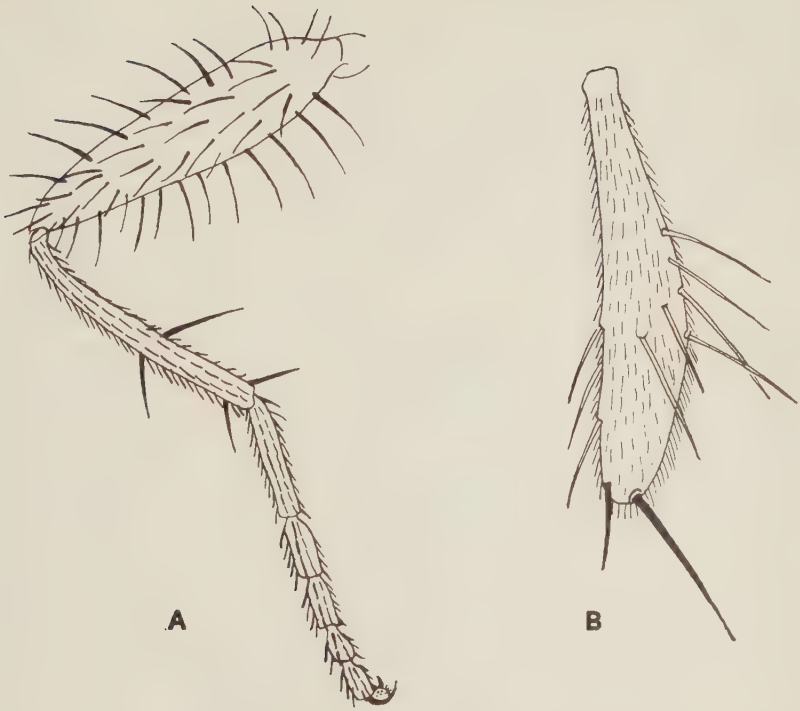

Fig. 4. Left fore leg and left maxillary palp of Trichopalpus punctipes Meig. ♀.
Vänster framben och vänster palp av Trichopalpus punctipes Meig. ♀.

yellow-brown part around the end of the femora is broad on *armillatum*. This species is also similar to *Trichopalpus fraternus* Meig. As regards *flavipes* the colour of the fore femorae is especially characteristic. As mentioned *A. flavipes* Fall. has often been confused with *Trichopalpus punctipes* Meig. But this species has completely yellow legs (also all femorae, fig. 4). The antennae and palpi are also entirely different in these two species (see fig.).

The egg.

No morphological distinction between the eggs of *armillatum* and *flavipes* is known, so the following description applies to both species. The length of the egg is about 1 mm. and the width about 0.2 to 0.3 mm. The colour is creamy (white-yellowish), the shape boat-like (fig. 5). The lower surface of the egg is convex, the upper one flat with a lengthwise ridge in the centre and strongly marked side-folds. The upper surface has an areolate structure.

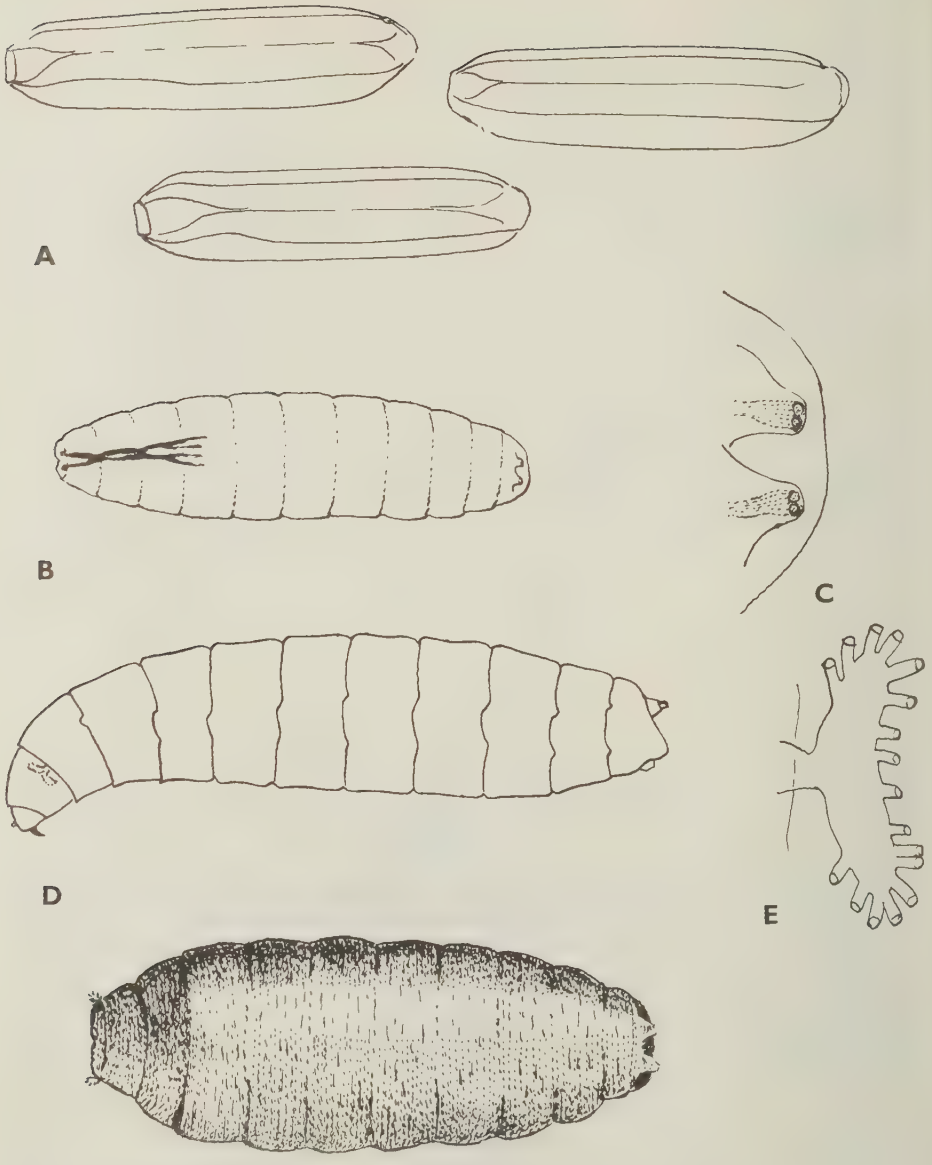

Fig 5. Developmental stages of A. f l a v i p e s Fall.; the natural size in brackets: A. eggs (approx. 1.0×0.2 mm); B. 4 days old embryo at time of hatching (approx. 1.0 ×0.25 mm); C. the caudal end of the former with the posterior spiracles; D. fully grown larva (approx. 6—7 mm in length); E. anterior spiracles of the former; F. the puparium (approx. 5.0×1.5—2.0 mm).

Utvecklingsstadier av A. f l a v i p e s Fall.; naturlig storlek inom parentes: A. ägg (ca 1,0×0,2—0,3 mm); B. 4 dagar gammalt embryo vid tiden för kläckningen (ca 1,0×0,25 mm); C. bakänden av den förra med bakre stigmata (andhål); D. fullväxt larv (ca 6—7 mm lång); E. främre stigmata av föregående; F. puppan (ca 5,0×1,5—2,0 mm).

The larva.

No fixed morphological distinctions between the larvae of the two species have been observed. The following description applies to *armillatum* as well as to *flavipes*. As is the case with the majority of flies, there are three larval instars. Common for these is, among other things, that they have a small head and 11 segments with discernable segment-limits, and that a well developed cephalo-pharyngeal skeleton has been formed. The larva, therefore, has the typical look of a fly-larva. A detailed description of the larval instars of *armillatum* is to be found in the paper by King, Meikle and Broadfoot (1935).

The first instar. The newly hatched larva is of about the same size as the egg. Three newly hatched larvae of each species had an average length of a little less than one mm. and were about ¼ mm. wide. The body is colourless and somewhat transparent. The black cephalo-pharyngeal skeleton is about ⅓ of the length of the larva, which means that it stretches into about the 4th segment. On the hind end of the body two protruding papillae with the spiracles can be seen. The fore spiracles are missing in the first larval instar which thus is metapneustic (fig. 5).

The second instar. According to King, Meikle and Broadfoot larvae of *armillatum* have a length of about 2.5 mm. in the second instar, and the cephalo-pharyngeal skeleton is a little smaller compared to the body, than in the first instar. A pair of anterior spiracles have formed, the larva is amphipneustic as in the third and last instar.

The third instar. The larva is 6 to 7 mm. long and about 1,5 mm. wide; the colour is yellow (fig. 5). The cephalo-pharyngeal skeleton is seen on the segment of the head as small black hooks. Immediately above these there are a pair of small maxillary palpi and a pair of small antennae. Between the first and second body-segment the anterior spiracles can be seen as tiny gill-like ramifications with 7 to 9 pairs of finger-like projections (fig. 5). On the hindmost border of the last segment the posterior spiracles are placed on two conic projections. On the ventral side of the last segment is the anus, caudally protected by two small warts.

The puparium. The pupa is enclosed in the last larval skin, the puparium. This is about 5 mm. long (ten specimens measured from 4.5 to 5.0 mm. in length and were about 1.5 to 2.0 mm. wide) (fig. 5). During the pupation the colour changes from a light brown to a reddish brown, which is the colour of the fully developed puparium. The fore part is relatively sharply cut off and in the fore corners the remains of the anterior spiracles of the larva can be seen. The posterior spiracles of the larva appear as two conical warts at the end of the puparium.

III. Distribution of Timothy grass flies

1. Total distribution

Timothy flies are mainly known from Europe. Most of the information about their occurrence comes from literature on economic entomology and confirms attacks by Timothy flies, but seldom gives particulars about the species which has caused the damage. According to literature where the flies have been identified, occurrences are:

A. armillatum Zett. in Sweden (Zetterstedt, Ringdahl), Norway (Ringdahl), Finland (Reuter), Germany (Wahl, Mühle), Russia (Karpova), England (Barnes) and Scotland (King and Meikle 1933). According to Sack the species occurs in Central and Northern Europe.

A. flavipes Fall. has been recorded from Sweden (Fallén), Norway (Schöyen 1891), Finland, Denmark, Germany, Russia, Siberia (Sack), Austria (Schiner), England and France (Séguy).

2. Distribution in Sweden

a. Geographical distribution.

From earlier statements about damage by Timothy flies in Sweden, it can not generally be seen which of the two species has caused the damage. Therefore these statements do not give any information about the exact distribution of the two species. Zetterstedt mentions in his description of *armillatum* that it occurs in Skåne (Southern part of Sweden) and Fallén describes *flavipes* on the base of specimens also caught in Skåne.

According to Ringdahl the present distribution in Sweden is:
armillatum: Skåne, Småland, Dalarna and Jämtland;
flavipes: Skåne, Småland, Gotland, Östergötland, Västergötland, Uppland, Värmland, Jämtland, Norrbotten, Lycksele and Lule Lappmark.

In the years 1950 –53 the writer received damaged Timothy grass from different parts of Sweden. A number of Timothy flies emerged from these samples. In some provinces nettings on Timothy fields were also carried out, and in this way a more extensive knowledge about the distribution of the flies has been obtained. Besides the provinces mentioned by Ringdahl, Timothy flies have been recorded in the following provinces (em = emerged flies, n = nettings):

A. armillatum Zett.: Halland (2 ♂, 1 ♀ n 24/5 1954[1]), Öland (11 ♂, 4 ♀

[1] Lampa (1893) had already reared *armillatum* from larvae collected in Halland.

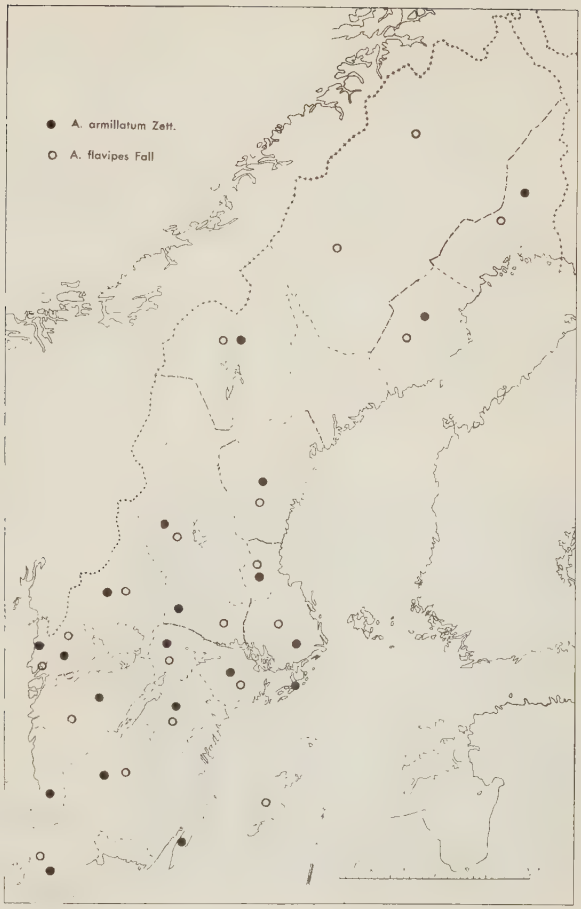

Fig. 6. The distribution of A. armillatum Zett. (●) and flavipes Fall (○) in Sweden.

Utbredningen av A. armillatum Zett. (●) *och flavipes Fall.* (○) *i Sverige.*

em), Östergötland (2 ♂, 2 ♀ em), Västergötland, Bohuslän (3 ♂, 3 ♀ n 23/5 1954), Dalsland (57 ♂, 58 ♀ n 25/5 1956), Närke (4 ♂, 11 ♀ n 14/6 1955), Västmanland (7 ♂, 10 ♀ n 31/5 1956) Södermanland (1 ♂, 6 ♀ n 1/6 1956 + 4 ♂ em), Uppland (1 ♂, 2 ♀ em), Värmland (20 ♂, 16 ♀ em), Gästrikland (1 ♂ em), Hälsingland (6 ♂, 9 ♀ em), Västerbotten (1 ♂ em), Norrbotten (1 ♀ em).

A. flavipes Fall.: Bohuslän (1 ♀ n 23/5 1954), Dalsland (56 ♂, 69 ♀ n 25/5 1956), Närke (7 ♀ n 14/6 1955), Västmanland (1 ♀ n 31/5 1956), Södermanland (9 ♂, 11 ♀ n 1/6 1956), Dalarna (12 ♂, 11 ♀ em), Gästrikland (2 ♂, 3 ♀ em), Hälsingland (41 ♂, 46 ♀ em), Västerbotten (1 ♂, 8 ♀ em).

As shown, the two species occur practically all over Sweden (fig. 6).

b. **Distribution within various habitats.**

From investigations on Timothy flies carried out in Västergötland it can be seen that either *armillatum* or *flavipes* prevails within a certain habitat. It is not known if this relates to Sweden as a whole.

In Västergötland Timothy flies were collected during the years 1950—55. Mature larvae were taken from Timothy grass growing partly on organic soil at the farms Dagsnäs and Trestena and partly on mineral soils near Skara. The number of emerged flies is shown in table 1.

Table 1. Emergence of larvae collected in organic soils and in mineral soils.
Tabell 1. Kläckningar av timotejflugelarver insamlade från mossjordar och från fastmarksjordar.

Emerged Year *Kläckta år*	Organic soils *Myrjordar*						Mineral soils *Fastmarksjordar*					
	Larvae from *Larver från*	armillatum		flavipes		Total *Summa*	Larvae from *Larver från*	armillatum		flavipes		Tota *Summ*
		No. *Antal*	Per Cent *Procent*	No. *Antal*	Per Cent *Procent*			No. *Antal*	Per Cent *Procent*	No. *Antal*	Per Cent *Procent*	
1950							Skara	63	92.7	5	7.3	68
1951	Dagsnäs	12	10.5	102	89.5	114	„	58	85.3	10	14.7	68
1953	Trestena	11	9.9	100	90.1	111						
1954	„	2	10	18	90	20	„	11	100	0	0	11
1955	Dagsnäs	3	1.5	192	98.5	195						
Total *Summa*		28	6.4	412	93.6	440		132	89.8	15	10.2	147

As can be seen, *flavipes* Fall. has been the prevailing species on organic soil the whole time, since between 89.5 and 98.5 % of the flies emerged belonged to this species. On the other hand *armillatum* dominated on mineral soils. The fact that *flavipes* prevail on organic soils and *armillatum* on mineral soils inside the area of investigation can also be clearly seen from the nettings. The results of nettings on organic soil at Dagsnäs is shown in figures 13—15. A series of nettings was carried out on mineral soil in the spring 1953 at Järnsyssla, Skara. Because of unfavourable weather and low frequency of flies only a small number of flies was caught. Between 8th and 13th of May sixteen specimens were caught; fifteen of these were *armillatum* (5 ♂ and 10 ♀) and 1 *flavipes* (♂). These figures indicate that *armillatum* prevailed on mineral soil there also. In nettings in Dalsland (1956) on May 25th, the following flies were caught: on organic soil 21 *armillatum* and 39 *flavipes*, and on mineral soil 60 *armillatum* and 11 *flavipes*. On another occasion, 1st of June 1956 in Södermanland, 6 *armillatum* and 17 *flavipes* were netted on organic soil.

IV. Biology

1. Emergence in the spring, sex ratio

To determine the emergence period of the flies, larvae of Timothy flies were collected during a period of five years in the field. The larvae were placed to emerge out-of-doors in sandy soil under natural conditions. To prevent them from creeping away, the larvae were placed inside a wooden frame. A couple of days before the anticipated time of emergence, when the larvae had hibernated, the frame was taken away and replaced by an emergence box (fig. 7) which was examined daily. The emergence periods

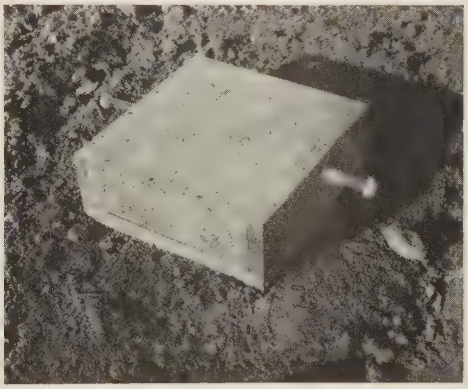

Fig. 7. Emergence box used for the investigations of the emergence period.

Kläckningslåda.

for 6 years can be seen from fig. 8. The number of flies which emerged per year is shown on the right. The length of the period is naturally dependent partly on the temperature and partly on the number of flies. As can be seen, emergence in Sweden generally takes place in the month of May. During the especially late and cold springs in 1955 and 1956 the emergence period did not occur until the later part of May and beginning of June.

A more exact picture of the course of emergence is to be seen in fig. 9 and 10, where the two flies have been separated in species, (*flavipes* above the horizontal line and *armillatum* below same) and in sexes. If the years where *both* species are best represented (1951, 1953 and 1954) are studied, it will be seen that *armillatum* and *flavipes* have emerged during the same period and that the emergence maximum of both species corresponds quite well. The emergence periods of both species correspond in other years too. Regarding *armillatum* as well as *flavipes,* it is a fact that both sexes as a

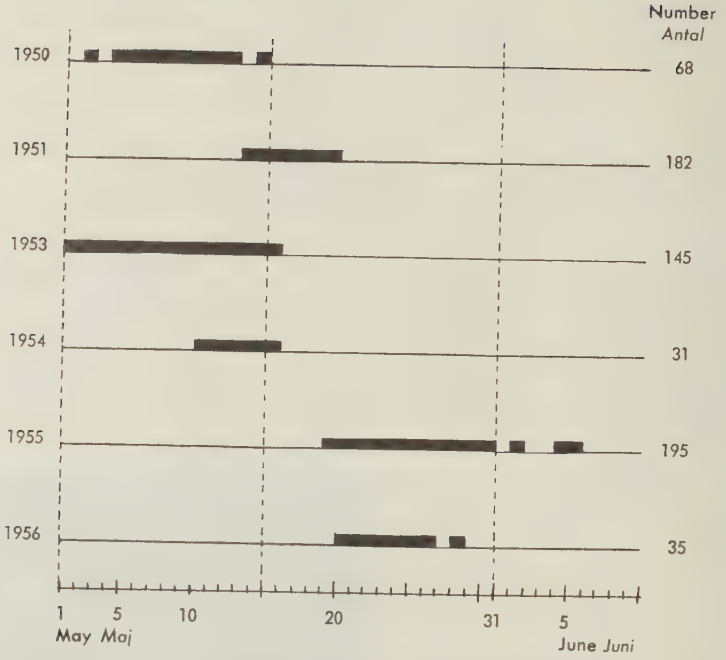

Fig. 8. A survey of the emergences of armillatum and flavipes in Skara 1950—56.

Översikt över timotejflugornas kläckning i Skara 1950—56.

whole emerge during the same period, but that the males predominate at the beginning of the period and the females towards the end.

The twenty-four hours'-rhythm during emergence has been investigated only once, in 1951, when three emergence-boxes were emptied every other hour for a space of forty-eight consecutive hours (18th and 19th of May). As only a rather small number of flies was obtained, the species were not separated. The experiment is shown in fig. 12, from which it may be seen that the principal emergence takes place in the morning with a minimum at night. During the period of observation both days were sunny. A very varied climate during the period of emergence would without doubt influence the course and change the above mentioned results.

Sex ratio.

In the number of larvae collected and reared near Skara males and females have appeared in about the same quantities, and this applies to both species. A comparison of the emergences has been made in table 2. As

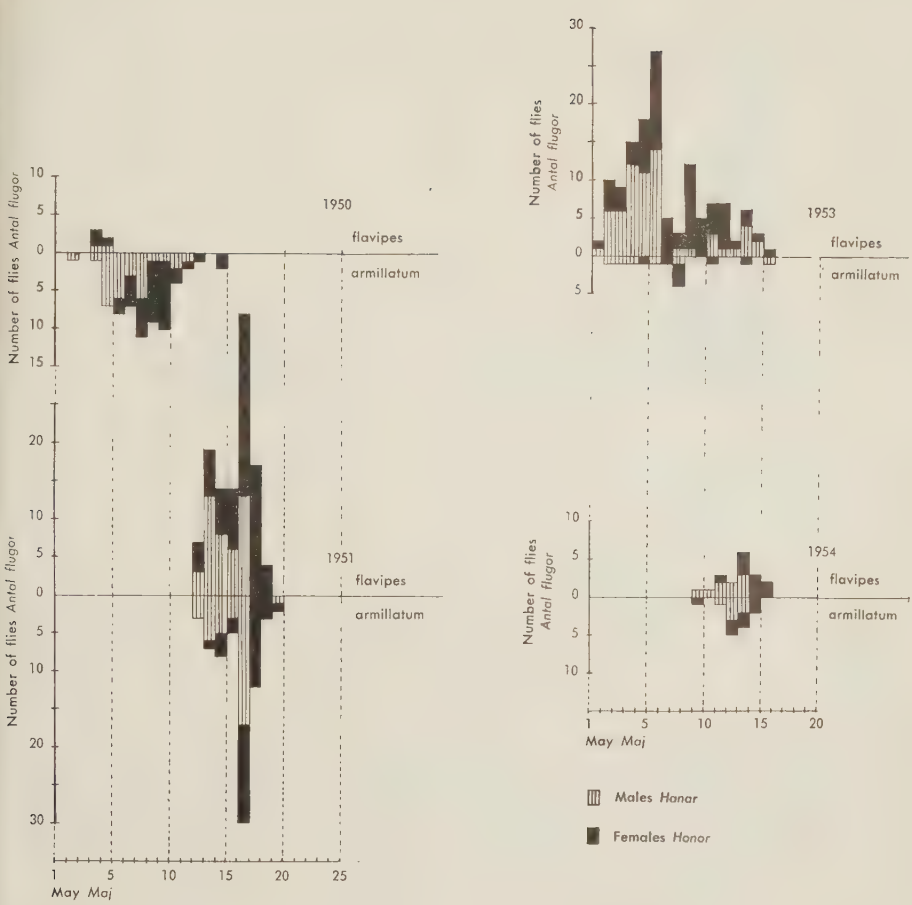

Fig. 9. Emergences of A. f l a v i p e s Fall. (above the horizontal line) and of A. a r m i l l a t u m Zett. (below the horizontal line) 1950—54.

Kläckningar av A. f l a v i p e s Fall. och av a r m i l l a t u m Zett., Skara 1950—54.

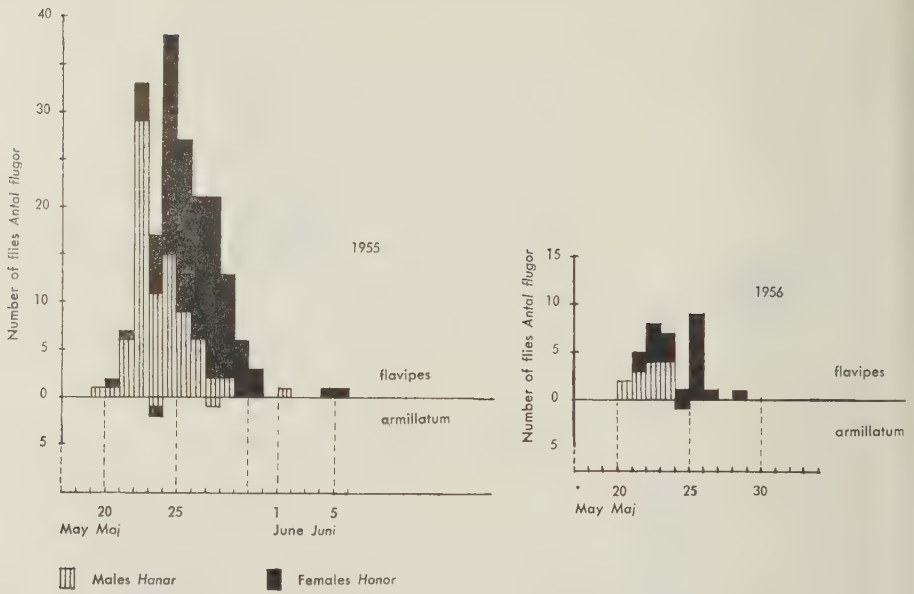

Fig. 10. Emergences of A. flavipes Fall. (above the horizontal line) and of A. armillatum Zett. (below the horizontal line) 1955—56. Organic soil.

Kläckningar av A. flavipes Fall. och av armillatum Zett., Skara 1955—56. Myrjord.

shown, out of a total number of 163 *armillatum* which emerged within six years, 50,9 % were females, and out of 493 *flavipes* which emerged during the same period, 57,2 % were females. That males and females appear in about the same numbers can also be seen from the nettings which have

Table 2. Emergences of Timothy flies 1950—56.

Tabell 2. Kläckningar i Skara 1950—56.

Year *År*	armillatum				flavipes			
	Males *Hanar*	Females *Honor*	Total Flies *Summa flugor*	Per Cent Females *% honor*	Males *Hanar*	Females *Honor*	Total Flies *Summa flugor*	Per Cent Females *% honor*
1950	29	34	63	54	2	3	5	—
1951	35	35	70	50	43	69	112	61.6
1953	7	6	13	46.2	63	69	132	52.3
1954	6	7	13	53.8	9	9	18	50
1955	2	1	3	—	81	111	192	57.8
1956	1	0	1	—	13	21	34	61.8
Total *Summa*	80	83	163	50.9	211	282	493	57.2

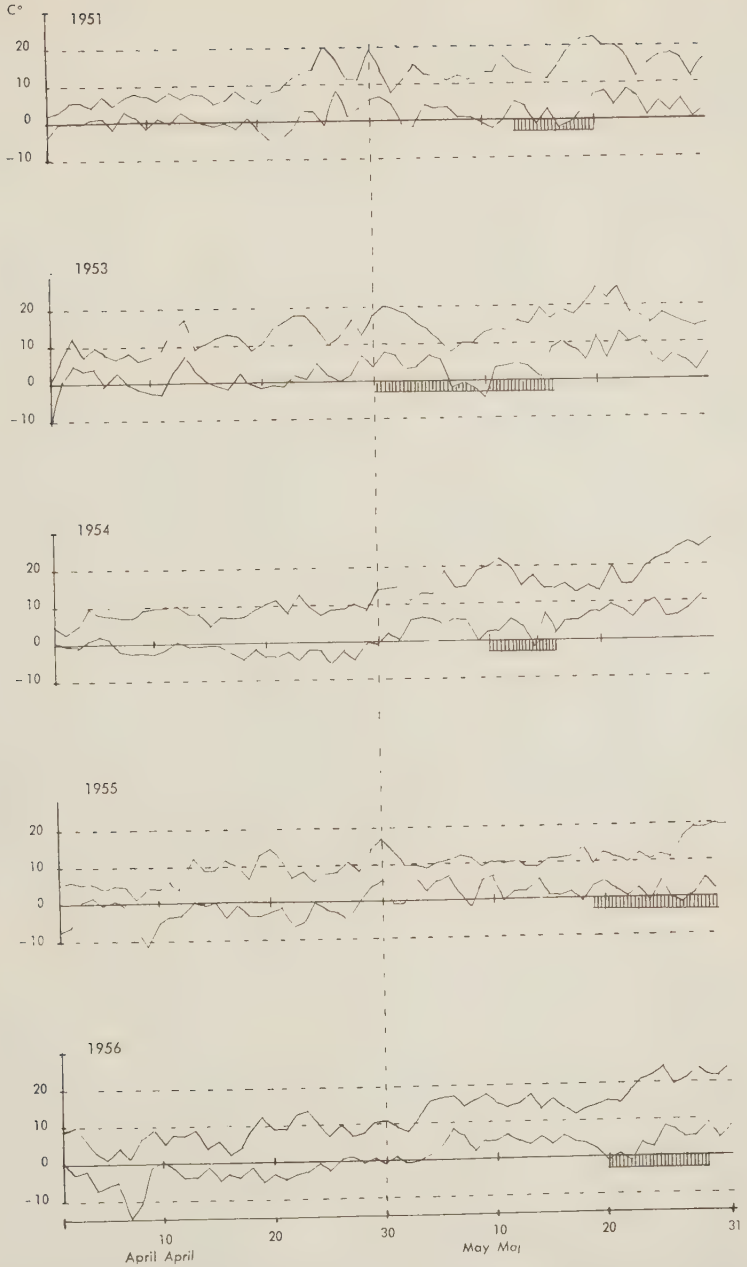

Fig. 11. Max. and min. temp. at Skara 1.8 m above the ground during 5 years. The emergence period of the Timothy grass flies=striped period.

Max- och min-temperatur i Skara (1,8 m ovan jord) under 5 år. Timotejflugornas kläckningsperiod=streckad period.

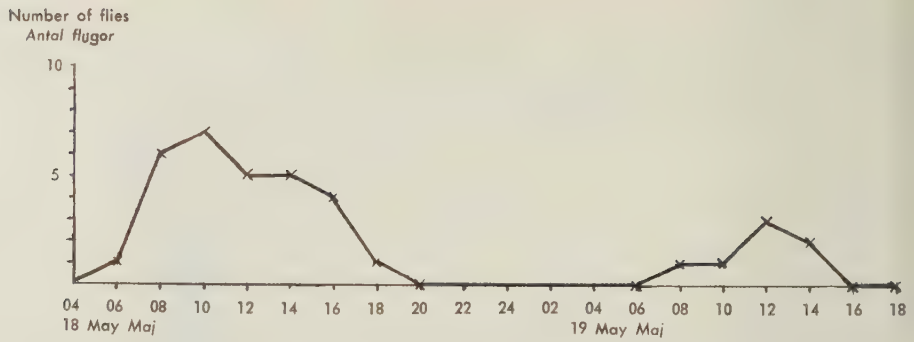

Fig. 12. Number of flies emerged May 18—19, 1951 during 38 hours in 2 hours intervals.
Kläckningsrytmen under 38 timmar 18—19 maj 1951 i 2-timmars perioder.

been carried out in Timothy fields near Skara, especially on organic soil at the farm of Dagsnäs, where these nettings have been performed over a period of six years. The nettings are illustrated in fig. 13—15 and the results are summarized in table 3. Out of a total of 971 *armillatum* caught by nettings, 49.6 % were females; and out of a total of 6.463 *flavipes*, 56.2 % were females. The results of the nettings correspond very well with those obtained from the emergences.

Even though the sex ratio is 1 : 1 or thereabouts, both sexes are not evenly represented during the full periods of emergence and flight. Thus the males prevail at the beginning and the females towards the end of emergence- as well as the flight-period. In fact, this is quite usual among Diptera. Thus e. g. Bremer and Kaufmann (1931) have shown that this applies to *Pegomyia hyoscyami* Pz. and according to Lundblad (1933) the males prevail among the *Hylemyia floralis* Fall. when emergence begins.

Table 3. Nettings in Timothy in organic soils, Dagsnäs.
Tabell 3. Frekvenshåvningar i timotej på myrjord, Dagsnäs.

Year *År*	armillatum				flavipes			
	Males *Hanar*	Females *Honor*	Total Flies *Summa flugor*	Per Cent Females *% honor*	Males *Hanar*	Females *Honor*	Total Flies *Summa flugor*	Per Cent Females *% honor*
1951	55	85	140	60.7	159	254	413	61.5
1952	36	33	69	47.8	171	190	361	52.5
1953	27	40	67	59.7	161	272	433	62.8
1954	144	152	296	51.4	770	1 379	2 149	64.2
1955	183	125	308	40.6	1 537	1 485	3 022	49.1
1956	44	47	91	51.6	35	50	85	58.8
Total *Summa*	489	482	971	49.6	2 833	3 630	6 463	56.2

2. Flight and Oviposition

Observations of the flight of Timothy flies have earlier only been carried out sporadically. Through investigations in Scotland KING, MEIKLE and BROADFOOT proved that Timothy flies (*A. armillatum*) were seen in the field for some years between May 11th and June 8th. WAHL states that during one year of observation the flight took place chiefly in May.

To be able to control a pest efficiently, it is naturally important to know as exactly as possible the time of its occurrence. By means of regular nettings the time of flight of Timothy flies was investigated during the years 1951—56. The nettings were principally carried out in Timothy fields, on organic soil, at the farm of Dagsnäs, to the South of the city of Skara in Västergötland. Some years nettings were also carried out on mineral soils. In this paper only the nettings at Dagsnäs will be reviewed as these are the most informative.

The net used has a diameter of about 32 cm. The plan was to net every other day during flight-time, but unfavourable weather prevented this sometimes. 100 sweeps were executed each time, divided into four series of twenty-five sweeps each. The samples from all the sweeps summarized are shown in diagrams (fig. 13—15). In these diagrams the sexes as well as the species have been separated. As can be seen, both species fly at the same time. Males and females may be seen in the Timothy grass during the entire time of flight, and, as stated above, males prevail at the beginning of the flight and females towards the end. The maximum number of flies caught during these six years is presented graphically in fig. 16. Some other results from the nettings at Dagsnäs 1951—56 can be summed up as follows ("catchday" means the day when the flies were netted):

Year	Species	First catch-day	Last catch-day	Approximate time of intense flight
1951	*flavipes*	15/5	18/6	17/5— 8/6
	armillatum	12/5	18/6	
1952	*flavipes*	5/5	5/6	7/5—27/5
	armillatum	7/5	5/6	
1953	*flavipes*	30/4	28/5	3/5—18/5
	armillatum	30/4	18/5	
1954	*flavipes*	10/5	4/6	14/5—31/5
	armillatum	10/5	4/6	
1955	*flavipes*	21/5	27/6	23/5— 6/6
	armillatum	21/5	23/6	
1956	*flavipes*	15/5	—	18/5—31/5
	armillatum	15/5	—	

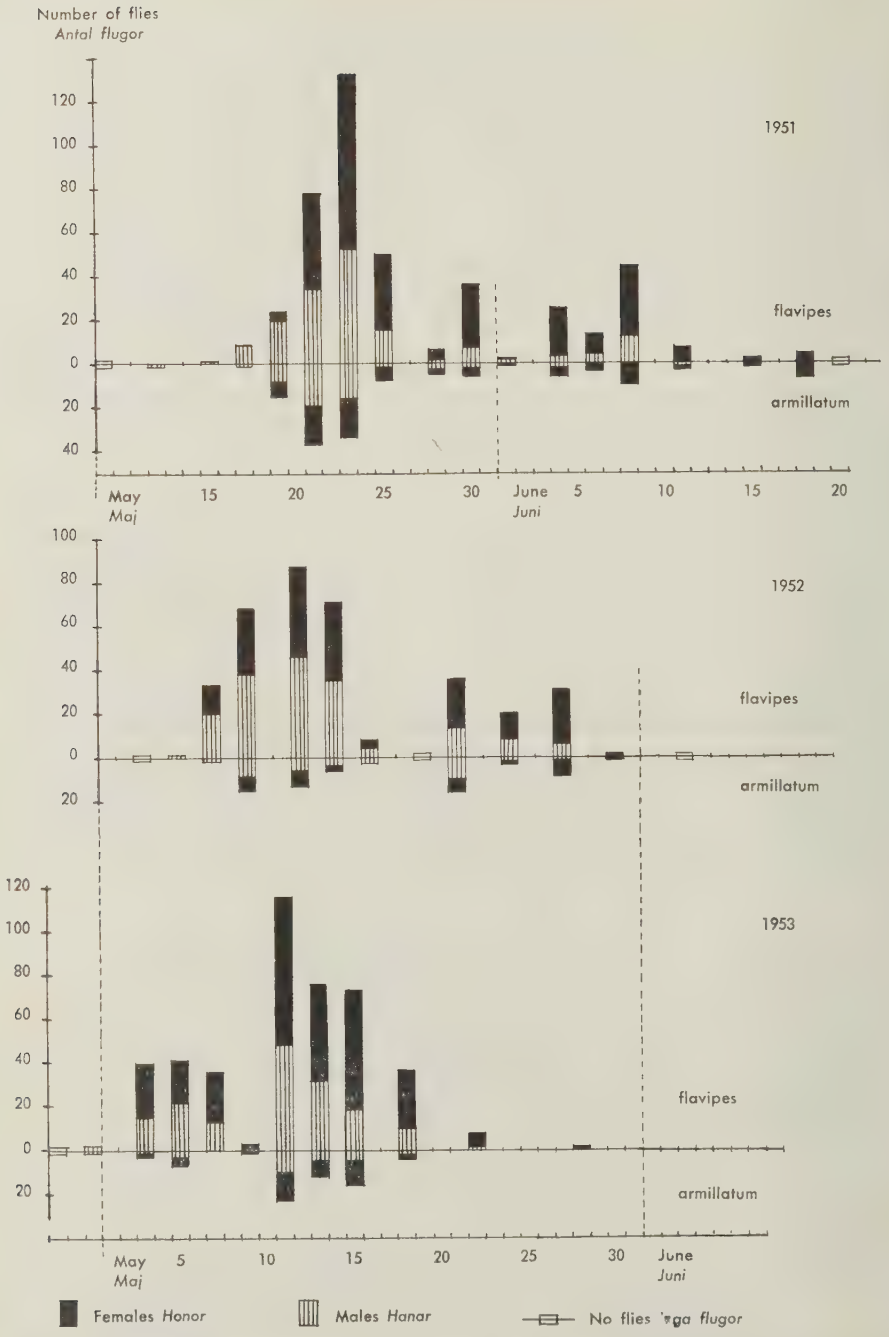

Fig. 13. Nettings in Timothy grass on organic soil, Dagsnäs 1951—53. F l a v i p e s Fall. above the horizontal line, a r m i l l a t u m Zett. below the same. 100 (4×25) sweeps.

Håvningar i timotej på myrjord, Dagsnäs 1951—53. F l a v i p e s Fall. ovan horisontallinjen, a r m i l l a t u m Zett. nedan densamma. 100 (4×25) håvslag.

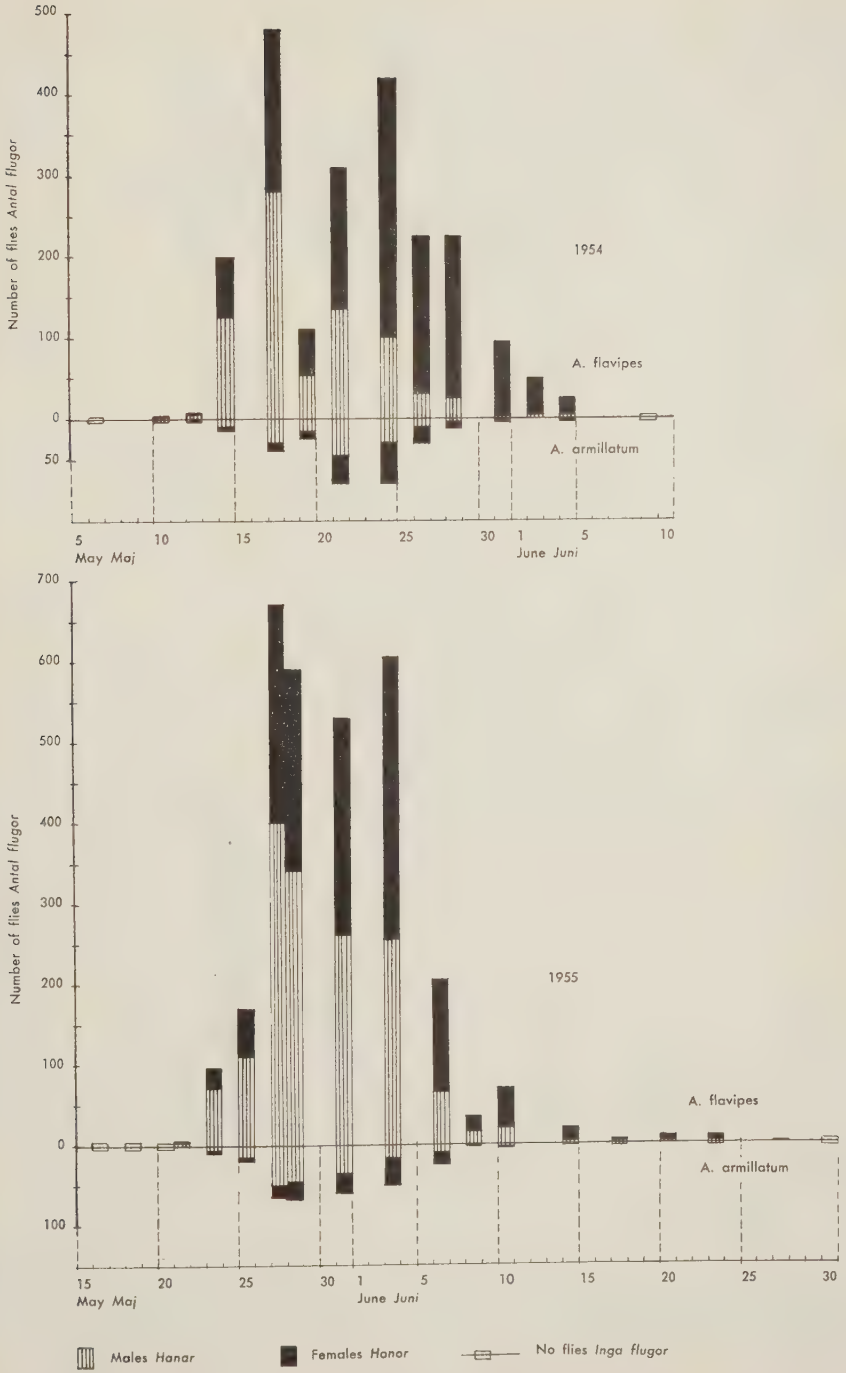

Fig. 14. Nettings in Timothy grass on organic soil, Dagsnäs 1954—55. F l a v i p e s Fall. above and a r m i l l a t u m Zett. below the horizontal line. 100 sweeps.

Håvningar i timotej på myrjord, Dagsnäs 1954—55. 100 håvslag.

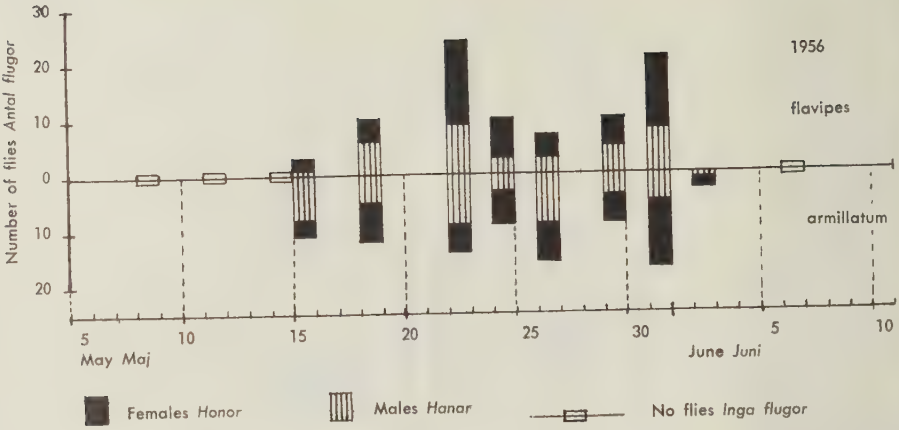

Fig. 15. Nettings in Timothy grass on organic soil, Dagsnäs 1956. F l a v i p e s Fall. above and a r m i l l a t u m Zett. below the horizontal line. 100 sweeps.

Håvningar i timotej på myrjord, Dagsnäs 1956. 100 håvslag.

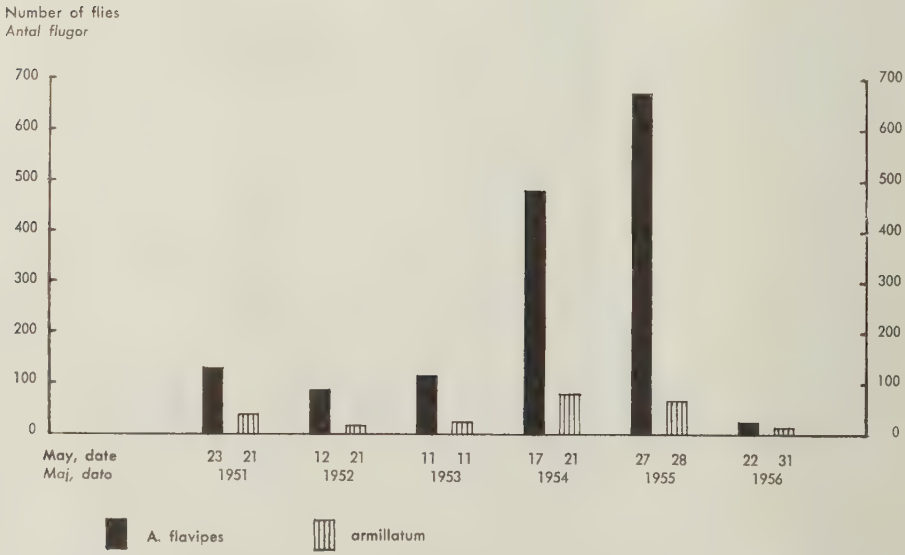

Fig. 16. Maximum number of flies caught per year (1951—56) in one netting (100 sweeps). Organic soils, Dagsnäs.

Max.-antalet flugor fångade under en håvningsdag (100 håvslag) 1951—56, myrjord, Dagsnäs.

In the year 1954, nettings in Timothy fields were also carried out in Northern Sweden, at the Branch Station of the Swedish Plant Protection Institute at Teg, Umeå. Only comparatively few flies were caught, but the results of the nettings give some evidence about the time of flight in the Umeå-area in comparison to that of Västergötland in a certain year.

Nettings at Teg, Umeå, 1954 (number of flies):

	22/5	25/5	28/5	31/5	3/6	7/6	9/6	12/6	15/6
armillatum	0	0	1	3	1	2	3	1	1
flavipes	0	1	4	1	2	3	2	4	1
total:	0	1	5	4	3	5	5	5	2

On June 12th, two females of *flavipes* were each seen carrying an egg half-way out of the ovipositor which proves that egg-laying was taking place at that time.

Oviposition. Through investigations in Scotland of *A. armillatum*, King, Meikle and Broadfoot noticed that this species flies for some days before oviposition begins. This is the case with both species in Sweden.

In connection with the repeated nettings, a number of females have been sorted out over a four year period and have been investigated with regard to the development of the eggs. The exact age of the females has not been determined, but the investigations are assumed to have given an average evaluation of the development of the eggs of the flies in the field. Regarding *flavipes* as well as *armillatum*, mature eggs have not been found in females until about 8 days after obtaining the first flies by nettings in the Timothy field. The greater part of the eggs in the ovaries only reached this stage after a further two days. The female is capable of holding about 50 mature, or almost mature eggs.

The eggs of the Timothy flies are comparatively easy to find on the Timothy in the field. The placing of the eggs on the plants has been described, among others, by Karpova, King, Meikle and Broadfoot and Wahl. For the oviposition, the female generally picks out one of the middle or upper green leaves of the Timothy plant. The egg is laid in the same way by both species, and generally on the upper side of the leaf, but also on the under side, or sometimes on the stem, or on the sheath of the leaf. Out of 115 eggs found in a Timothy field 63 had been laid on the upper side of the leaves, 33 on the lower and the rest on other parts. The egg is generally placed next to the ligule (fig. 17), it is less often laid some centimetres out on the leaf. The eggs are always placed parallel to the veins of the leaf and are laid one by one. On plants with eggs, generally no more than from one to three eggs are to be found. In fields where a

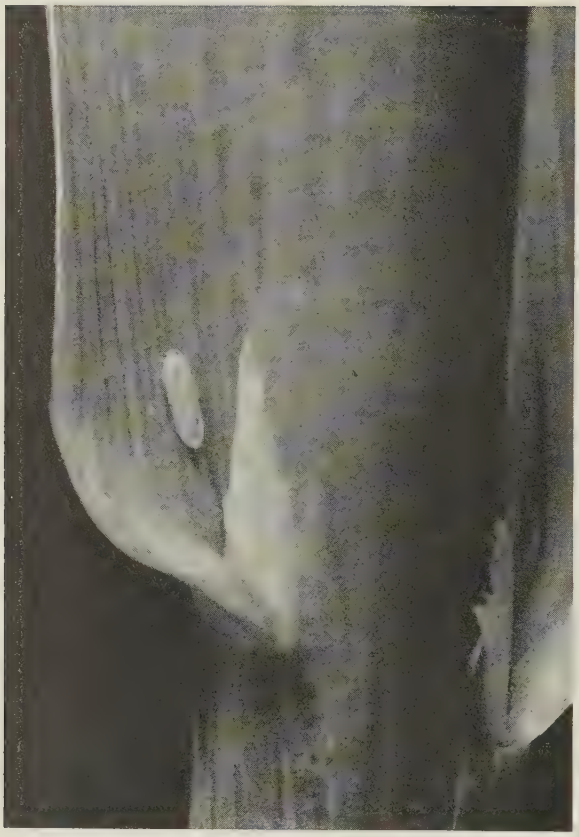

Fig. 17. Egg of Amauro-soma sp. in typical position on a leaf of Timothy grass.

Timotejflugeägg i typiskt läge nära basen av ett timotejblad.

great number of flies occur, e. g. in years when these flies appear in masses, one may find from four to six eggs on one plant. In cultures a far larger quantity of eggs may be found on isolated plants.

3. Development of the egg and the larva; pupation

In Scottish investigations by King, Meikle and Broadfoot the egg and larva development of *A. armillatum* has been studied. Eggs laid on plants in the laboratory hatched after four to six days and also in laboratory-tests the larva needed about a fortnight for its development. In order to investigate conditions here more closely, fully developed flies were caught in Timothy fields and isolated on Timothy plants, generally a number of flies of the same species per culture (fig. 18). The plants were examined every twenty-four hours, and as soon as eggs had been laid on them, they were isolated in a box where the plants and the eggs were kept under observation. The investigations were carried out in an insectary with the

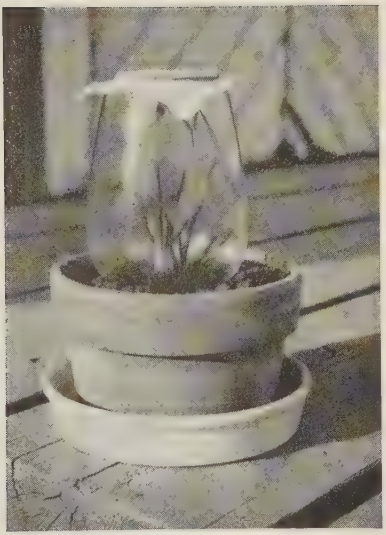

Fig. 18. Culture with Timothy grass and egglaying flies.

Kultur med äggläggande timotejflugor.

same temperature as that outdoors. When the flies caught carry mature eggs, it is very easy to induce them to lay eggs. Whether an egg has hatched or not can only be established with certainty through dissection, if it is not observed at the moment of hatching; this latter, however, was never the case although more than 200 eggs were examined.

Development of the egg. It was not possible to determine any definite difference in the time of development of the eggs of the 2 species.

Out of 16 newly laid eggs of *armillatum*, later dissected and examined, 10 had hatched after four and a half to six days, six had not hatched after three to five days. The development of these eggs is set down in table 4, and the approximate temperature during the days of development is illustrated by comparing the notes on maximum- and minimum-temperatures at the bottom of the table. Summing it up, one can say that the egg of *armillatum* normally takes from four to six days to hatch.

When 45 eggs of *flavipes* were examined and dissected, 25 were found not to have hatched after three to six days, and 20 eggs had hatched after five to six days. The development of 15 eggs of *flavipes* has been illustrated in table 4 as well as maximum- and minimum-temperatures during the development of these eggs. As will be seen from a closer comparison of the values of the table, the temperature naturally influences the period of hatching. Thus, 7 eggs (*flavipes*) had not hatched after six and five days in cultures 1952, while in cultures 1953 5 eggs (*flavipes*) had hatched after five days, as the temperature was higher in the latter case than in

Table 4. Development of the egg (N = Not hatched, H = Hatched at dissection).

Tabell 4. Äggutvecklingen (N = ej kläckt, H = kläckt vid dissektionen).

Species *Art*	No. of eggs *Antal ägg*	Egg laid *Ägg lagt*	Dissec. *Dissek.*	Days *Dygn*	N/H
armil-		1953			
latum	1	15/5	19/5	4.5	N
„	1	15/5	19/5	4.5	H
„	5	15/5	21/5	6	H
„	1	16/5	19/5	3	N
„	3	16/5	21/5	5	H
„	1	17/5	22/5	5	H
		1954			
„	4	27/5	1/6	5	N
		1952			
flavipes	1	24/5	30/5	6	N
„	6	25/5	30/5	5	N
		1953			
„	3	16/5	22/5	6	H
„	5	17/5	22/5	5	H

Temperature reports:
Temperaturuppgifter:

1952 May (*maj*), date (*datum*):		*24*	*25*	*26*	*27*	*28*	*29*	*30*	
Degrees C (*grader*)	max :		24		18.5	11.0	13	12.5	
	min :	8.5		−1		8.5	3.5	3	
1953 May (*maj*), date (*datum*):		*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*
Degrees C (*grader*)	max :	20	20	19.2	18.8	21	26	22.2	25.8
	min :	0.9	8.8	8	9.7	5.5	11.6	6.2	12

the former. Summing up the test results, it can be seen that the eggs of *flavipes* generally hatch after about five days (Central Sweden).

Development of the larva. No definite distinctions have been established between the two species regarding the time of development of the larva. In the field it can be verified that the larva is fully grown when the ears appear on the grass. Shortly after that, the larva leaves the plant to creep into the soil. There may be some difference in the time of development for larvae which hatched from the first and last eggs. In cultures in 1950 where the development of the larvae was studied, the larvae were fully grown towards the middle of June, after about twenty-eight days from the oviposition on May 17th and 18th, but after only twenty-two and twenty-three days in cases where the eggs had been laid on May 22nd and 23rd. The time of development of the larvae can be said to be dependent on the

time between oviposition and the time of the formation of the ear. In cultures in 1951 the ears appeared between fifteen and twenty-three days after oviposition, and larvae of both *armillatum* as well as *flavipes* reached their full grown stage after about fifteen days.

Pupation: At the heading stage of the Timothy the full-grown larvae pupate in the soil. According to King, Meikle and Broadfoot the larvae of *armillatum* pupate after three to fourteen days. In experiments carried out by the writer on June 30th, 1951, with 50 larvae of Timothy flies (mixed population of *flavipes* and *armillatum*, but mainly the former species), no

Fig. 19. Puparia of Amaurosoma sp. (nat. size approx. 5.0×1.5—2.0 mm).

Puppor av timotejfluga (nat. storlek ca 5 mm i längd).

larvae had pupated after one day, 33 larvae (66 %) after two days and 49 (98 %) after three days. The 50th was dying on the 4th day of the experiment. When experimenting one may obtain some variation in the time of pupation due to the fact that the larvae collected for experiments are of somewhat varying age, although they are all "full-grown". This may explain the variation between the results obtained in Scotland and those of the writer. In the latter case the larvae seemed to be of almost exactly the same age.

To investigate at which soil depth pupation takes place, an experiment with larvae was carried out. On 17th of June, 1950, 290 larvae were placed in three wooden tubes filled with soil. The tubes were called nos. I, II and III. They contained different sorts of soil, namely I: clayey soil, II: sandy soil and III: organic soil. 90 larvae were placed in no. III, in the two others 100 larvae in each. The larvae were placed in the tubes on top of the soil after the soil had been somewhat moistened. On 2nd and 3rd day of August

(1950), the soil of the tubes was examined. The tubes were constructed in such a way that the soil could be taken out in layers of 2.5 cm. The examination showed that all larvae found had pupated. Most of the pupae were placed as seen in table 5, in the upper layer (0 to 2.5 cm.), and this

Table 5. Vertical distribution of pupae in the soil.

Tabell 5. Puppornas vertikala utbredning i jorden.

Depth in cm *Djup i cm*	Number of refound pupae *Antal återfunna puppor*		
	I	II	III
0 — 2.5	63	59	71
2.5— 5	28	24	4
5 — 7.5	0	7	0
7.5—10	0	1	0
10 —12.5	0	0	0
12.5—15	0	0	0
15 —20	0	0	0
Total *Summa*	91	91	75

was especially pronounced in the tube with organic soil. Some larvae were also found in the second layer (2.5—5 cm.), but deeper down only a very few (see table). Both species hibernate as puparium.

4. Host plants

The natural host plant for larvae of *A. armillatum* and *flavipes* is Timothy (*Phleum pratense*). Records can be found about attacks by Timothy flies on other plants also, e. g. winter rye, barley and wheat.

The fact that rye can be found serving as a host plant for Timothy flies is mentioned for the first time by Lindeman from Russia. If he really did find larvae on damaged rye, or if his statement is based upon symptoms found on the ears of rye, is not quite clear. It cannot be considered entirely unreasonable to look upon the statement with some reservation, as the determinations and descriptions by Lindeman have been made exclusively about flies which emerged from larvae collected on Timothy. Reuter states that he, like Lindeman, has found larvae of Timothy flies on rye in Finland, but only very seldom. Reuter does not say that he had reared the flies. Thus, this statement about the damage having been caused by Timothy flies cannot be considered confirmed. From Russia Yaroslavtzev (1928) and Karpova report attacks by *flavipes* on rye. Znamenskaya (1941) reported damage by *flavipes* on barley and wheat in Murmansk. Lindeman writes that he has observed damage by Timothy flies on *Festuca gigantea*. Mühle

states that attacks by Timothy flies were reported to Biologische Reichsanstalt on *Agrotis alba, Dactylis glomerata, Festuca rubra* and *Poa pratensis,* but in his own observations he found attacks only on Timothy grass. In discerning investigations on Timothy flies from later years, although not including speciality tests on different host plants, as e. g. by Barnes, King, Meikle and Broadfoot and Wahl only Timothy is reported with certainty as a host plant for *armillatum* and *flavipes.*

In Sweden *only Timothy* has been proved to be a host plant for the two species. Over a period of two years the writer carried out some experiments with different host plants. Egg-mature females had been caught in Timothy fields and were later isolated on couch-grass (*Agropyron repens*) (a culture with ten females of *flavipes,* and one with about ten females from both species); on rye (three cultures with a total of 25 females of *flavipes*); on rye + Timothy (a culture with eight females of *flavipes*) and on wheat + Timothy (a culture of three females of *armillatum*). Each experiment was carried out for at least two days during periods when the Timothy flies were laying their eggs very readily on Timothy grass, whereas oviposition did not occur on any of the other plants in the experiment.

Damage to plants other than Timothy grass that has been reported as caused by Timothy flies, has probably sometimes been confused with other causes, e. g. frost injury. Karpova shows an illustration of an ear of rye damaged by Timothy fly larvae. According to symptoms, this damage is very similar to that caused by frost, which, in Scandinavia as well as in Northern Europe, very often appears on e. g. rye (Borg 1953) and barley; and is the same as the damage which has been scientifically reproduced by Sorauer (1914) in a field trial with the freezing of rye. Various statements in literature about attacks by Timothy flies on other plants than Timothy grass which are exclusively founded on the symptoms of the attack, must, therefore, be considered very doubtful.

5. Parasites

Only some parasite wasps are known as parasites of Timothy grass flies. Reuter reared an unidentified *Pteromalid* from larvae collected in Finland, and King, Meikle and Broadfoot reared the Pteromalid *Seladerma laetum* Walk. and the Braconid *Ectilis* (*Dacnusa*) *semirugosa* Hal. Barnes reports *Microbracon exhilarator* Nees and a *Lamprotatus*-species as parasites of *Amaurosoma,* and adds that the latter appears to be the more common in England.

From Swedish material (*A. flavipes* Fall. and *armillatum* Zett.) the writer has reared several parasites. Most of them have been identified, the Chalcidids by Dr Vittorio Delucchi and the other parasites by Mr Karl Johan Hedqvist. For this kind and very valuable help, the writer

wishes to express his warm gratitude to Dr Delucchi and Mr Heqvist. The determined species are:

Chalcidoidea (*Pteromalidae*):

Subfam. *Lamprotatinae*:	*Stictomischus gibbus* Walk.
	Seladerma laetum Walk.
Subfam. *Pteromalinae*:	*Stenomalina* sp.

Braconidae:

Subfam. *Alysiinae*:	*Chasmodon apterus* Nees
	Mesocrina venatrix Marsh.
Subfam. *Dacnusiinae*:	*Rhizarcha areolaris* Nees.
	Dacnusa cincta Hal.
	Ectilis (*Dacnusa*) *semirugosa* Hal.

Cynipoidea:

Subfam. *Eucoilinae*:	*Eutrias tritoma* Thoms.

Ichneumonidae:

Subfam. *Ophioninae*:	1 sp., not identified

According to information from Heqvist this occurrence of *M. venatrix* is the first one recorded in Sweden. As far as the writer has been able to find no host has earlier been known for *S. gibbus, D. cincta, C. apterus* and *M. venatrix. Seladerma laetum* and *E. semirugosa* have been reared in several specimens from material from different places in Sweden. They are therefore to be considered as important parasites of the Timothy grass flies in our country. As a rule both *E. semirugosa* and *S. laetum* appear to emerge from puparia of *Amaurosoma* somewhat later than *armillatum* and *flavipes*. Of the two parasites, *E. semirugosa* emerged a little earlier than *S. laetum*. The emergence periods for two years were as follows:

1951	Emergence-period	Number of animals
A. flavipes / *A. armillatum*	May 13—20	182
Ectilis semirugosa Hal.	» 22—30	28
Seladerma laetum Walk.	June 4—15	33
1955		
A. flavipes / *A. armillatum*	May 19—June 1 (5)	195
Ectilis semirugosa Hal.	June 3—14	29
Seladerma laetum Walk.	» 10—30	45

As shown in chapter VI which deals with the chemical control of Timothy grass flies, and which is also presented graphically in fig. 24—27, a DDT-

spraying in Timothy results in a fair residual effect for about fourteen days, and a Parathion-spraying for about six days. If the application is carried out at the right time, i. e. at the beginning of the emergence period of the flies, one spraying with DDT will have a detrimental effect on *E. semirugosa* and especially on the earliest emerged wasps of this species. *S. laetum,* on the other hand, has greater chances to escape the toxicity of a DDT-spraying since the residual effect of the material will have decreased considerably by the time this wasp flies.

Besides the above mentioned wasps, some further, not yet identified species, have been reared in single specimens.

In Sweden parasitic wasps, particularly of the species *S. laetum* and *E. semirugosa,* occur as a rule in Timothy grass crops in such numbers, that a natural biological control of practical value ensues. Control by means of DDT should therefore not be undertaken, unless there are very strong reasons for a chemical control, as in years with mass occurrence of these pests. The DDT control should also be carried out early in the proper control period. In this way the risks of the residual effect of DDT will be minimized.

V. Damage by Timothy flies

1. Extent of the damage on the ear

Directly after emerging the young larva seeks the ear inside the sheath. It eats its way into it and during the entire larval period it stays there and feeds upon the flower parts. The axis of the ear is not damaged nor the stem itself. As the larva leaves the ear at the heading stage, the ear continues to grow after the larva has left. Probably dependent on e. g. the age and development of the ear when the young larva starts feeding on it, the damage may be more or less severe. In some cases not more than about 20 % of the flowers are damaged, in other cases the injury may be total. Sometimes the damage is a partial stripping of the flower head, sometimes a more general damage to the whole length of the ear. In the latter case the injury is done more or less spirally; it developes into a trail

Fig. 20. Timothy ears attacked by larvae of Timothy grass flies.

Timotejax skadade av timotej-flugelarver.

showing where the larva has eaten its way along the ear. The damage is identical for both species. Generally, there is only one larva per damaged ear, but sometimes two, and in rare cases three larvae can be found on the same ear.

The flowers on the ear which have not been damaged by the larva develop normally into seeds. KARPOVA and WAHL state that an average of about 50 % of the seed is lost on damaged heads. These statements tally well with conditions in Sweden. In two cases (1950 and 1951), 300 undamaged and 300 damaged ears were collected, the seeds picked and weighed. The Timothy was taken on organic soil where *flavipes* had been the prevailing species. The result is shown in table 6, and as will be seen, about 50 % of the seed has been lost in the attacked ears.

Table 6. Effect of the attack on the seed harvest.

Tabell 6. Angreppets inverkan på fröskörden.

	Seed in gram *Frömängd i gram*	
	Sample I (cleaned) *Prov I (rensat)*	Sample II (not cleaned) *Prov II (orensat)*
a. 100 not damaged ears ... *ej angripna ax*	9.8	16.2
b. 100 „ „ „ ...	10.4	16.6
c. 100 „ „ „ ...	11.7	16.0
Total „ „ „ ... *Summa*	31.9 g	48.8 g
d. 100 damaged ears ..... *skadade ax*	5.4	8.3
e. 100 „ „	5.2	7.8
f. 100 „ „	5.5	9.0
Total „ „ ..... *Summa*	16.1 g	25.1 g

2. Damage in seed crops

Attacks by Timothy flies in seed crops have been mentioned from Russia (LINDEMAN, KARPOVA, ZNAMENSKAYA and others), Germany (WAHL, MÜHLE), France (BALACHOWSKY and MESNIL), England (NEWTON 1932, BARNES), Scotland (KING, MEIKLE and BROADFOOT), Denmark (LIND et al. 1916, ROSTRUP 1940), Norway (W. M. SCHÖYEN 1891—1912, T. H. SCHÖYEN 1913—41), Finland (REUTER and others) and from Sweden (see below).

From literature one gets the impression that heavier attacks occur more often in Northern Europe than in Central Europe.

Damage in Sweden: In Sweden attacks by Timothy flies were reported as early as around the year 1890 by LAMPA and, later, inter alia by the reporters of the Plant Protection Institute of Sweden working in the provinces. From 1911 up to 1954, about 700 reports about attacks by Timothy flies were received by the Institute from all Swedish provinces except the island of Gotland. These reports do not give an exhaustive picture of the extent of the attacks throughout the country, but they do at least locate some of the areas and the years of the attacks. The provinces from which most of the reports mentioned have been received during said period are as follows (in brackets number of reports or letters):

province of Jönköping (70), Älvsborg (66), Skaraborg (60), Värmland (93), Örebro (45), Södermanland (32), Stockholm (31), Västernorrland (39), Jämtland (46) and Västerbotten (33). From Skåne, Blekinge and Halland only a few reports have come in during the time mentioned (1911—1954).

According to the reports, Timothy flies are very seldom a problem in Southern Sweden, while in the Central and Northern parts attacks occur very often.

In the years 1911, 1912, 1922, 1931, 1932, 1937, 1938 and 1939 a comparatively greater number of reports have been received than in other years. As pointed out by JOHANSSON (1938), the attacks by Timothy flies occur periodically, i. e. they are repeated for some years and then stop for a while. Taking Sweden as a whole this periodical tendency is not very distinct, probably because it depends, amongst other things, on climatic conditions; these may one year be more favourable to the flies in one part of the country than in another. In table 7 a comparison has been made of the years when the severest attacks by Timothy flies were reported to the Institute, showing the areas where these attacks took place. The force of the attack is shown in the approximate percentage of damaged ears.

As may be seen from table 7, severe infestations occurred in the years 1912—13, 1919—22, 1930—32 (especially in Norrland), 1937—40 (severe infestations all over the country) and 1951—52 (Norrland). The periodical tendency is not so absolutely regular that it can be used for instance for warning purposes, but as it is obvious that attacks as shown above generally occur over a number of consecutive years after the first one, this fact must naturally be kept in mind.

From the table it may also be seen that attacks, not only during periods of infestation, are often of serious extent, so that many farmers have reported damages amounting to 50—90 %. From the reports on Timothy flies received by the Institute it is clear that not only a few fields of Timothy grass have been damaged by attacks during some years, but practically

Table 7. Severe attacks by Timothy flies in Sweden 1900—1954.

Tabell 7. Starkare angrepp av timotejfluga i Sverige 1900—1954, enligt Lampa och efter rapporter till Statens växtskyddsanstalt.

Year *År*	Area and extension of the damage (approx. percentage of damaged ears) *Område samt skadans omfattning (ungefärlig procent skadade ax)*
1905	Stockh. l.
1906	Västerg. l. (50 %), Hall. l.
1912	Gävleb. l. (40 %), Värml. l. (25 %), Stockh. l. (50 %), Österg. l., Jönköp. l. (50 %)
1913	Upps. l. and Södermanl. l. (50 %), Västernorrl. l. (75 %)
1917	Älvsb. l. (50—60 %)
1919	Södermanl. l. and Kopparb. l. (50 %), Västernorrl. l. (10—75 %), Upps. l. (50 %)
1920	Malmöhus l. (50 %), Södermanl. l., Gävleb. l. (50—60 %), Västernorrl. l.
1922	Gävleb. l. (50—80 %), Stockh. l., Jönk. l. (60—70 %), Örebro l., Södermanl. l. (90 %), Älvsb. l. (25 %), Upps. l. (50—75 %)
1924	Värml. l. (30—60 %), Kopparb. l.
1926	Jönköp. l. (75 %), Göteborgs and Bohus l. (50 %)
1930	Älvsb. l. (10—90 %), Kopparb. l. (40 %), Västerb. l.
1931	Österg. l. (70 %), Älvsb. l. (60 %), Stockh. l. (50 %), Jämtl. l. (25—80 %)
1932	Jönköp. l. (20—50 %), Jämtl. l. (25—75 %), Västernorrl. l. (25 %)
1937	Jönk. l. (40 –70 %), Gävleb. l. (50 %), Kalmar l. (50 %), Värml. l (40—75 %)
1938	Jönköp. l. (60—90 %), Skarab. l. (20—50 %), Älvsb. l. (75—90 %), Örebro l. (70 %), Södermanl. l., Värml. l. (50—90 %), Kopparb. l. (50 %), Gävleb. l.
1939	Hall. l. (50 %), Kronob. l. (50 %), Jönköp. l. (50—70 %), Skarab. l. (50—75 %), Älvsb. l. (70—90 %), Södermanl. l., Värml. l., Västmanl. l. (30 %), Västernorrl. l.
1940	Skarab. l. (50—75 %)
1941	Älvsb. l. (50 %), Skarab. l. (25—75 %)
1950	Kopparb. l. (50—75 %)
1951	Gävleb. l., Norrb. l. and Västerb. l. (50 %), Västernorrl. l.
1952	Kristianst. l. (50 %)

all Timothy fields in certain provinces have been heavily attacked, as may be seen e. g. from the reports from the valley of the Ångerman river in Northern Sweden (1920), from Uppland (1922) from Gästrikland and Värmland (1937) (about 40- 50 % attacks), from Dalsland (1938) (up to 75 % attacks) and from Northern Halland (1940).

Amongst the relatively great number of reports and notices about Timothy flies received by the Institute during the years mentioned, many interesting statements from experienced cultivators and others are to be found. Some of these observations will be mentioned here.

To prevent severe attacks by Timothy flies it is recommended in some manuals (Rostrup, Stapel 1946, Lindfors and Tunblad 1947) that Timothy

should not be cultivated in the same field more than 2 years running. The effect of this as prevention against attacks by Timothy flies is, however, very uncertain, and even more so when one studies the 700 reports. Unfortunately, only a few of these reports mention the age of the Timothy field. But the statements seem to indicate that serious attacks by Timothy flies occur in first or second year fields as often as in older ones. It is therefore doubtless more correct to say, as in several reports, among others one from Västergötland (1939): "The damage appears to be equally severe in first year fields as in fields of two, three or four years." The damage the reporter had in mind had been rated at 80—90 % damaged ears.

There are no statements in the reports about the resistance of different varieties of Timothy grass. On the other hand, some useful opinions on the importance of the soil are given. In several reports it is said that the worst attacks occurred in organic soils and in wet fields. A reporter from the district of Stockholm 1930, says: ". . . Without doubt a third of the crop has been destroyed in the fields near lakes and water courses . . ." From the results of the investigations on the occurrence of the flies in different habitats, the above mentioned fact that the heaviest attacks have been reported from organic soils and the like e. g. fields next to water, could supposedly be explained by these attacks being caused by *A. flavipes* which principally occur in habitats of this kind. On the other hand, other reporters state that the attacks have mainly occurred in "high-level, dry fields" or in mineral soils. In the latter case the damage has surely been caused mostly by *armillatum*. As is to be expected, there are also reports mentioning attacks on different types of soils. In these cases *armillatum* as well as *flavipes* has without doubt occurred. There are no reports of Timothy grass on clayey soil with serious damage, and this may agree with what K. F. Johansson, Kristinehamn, reported on July 14th 1939: "Completing an earlier report about Timothy, a closer inspection has shown that Timothy flies seem to be most aggressive on Timothy growing in black or organic soil and lighter sandy soil. Timothy on clayey soils appears to be free from this insect according to observations having been made now during harvesting time."

From the reports, however, it may clearly be seen, that in Sweden severe attacks by Timothy flies have occurred as much on grass growing in organic soils or the like as in mineral soils. From the reports it may therefore also seem that *armillatum* as well as *flavipes* can occur in such great populations of one or of both species at the same time and that infestations of economic importance can occur.

VI. Control of Timothy flies

1. Cultural control

Even older literature gives some advice about how to lessen the attacks by Timothy flies in seed crops. Lampa (1899) says about this pest: "The only imaginable means of extermination would be to cut the Timothy grass before the heading stage, while the larvae are still only half grown." By doing this the further development of the larvae could be prevented, and the attacks the following year lessened. Lampa also puts forth the same idea later, as does W. M. Schöyen (1891—1912) and Tullgren (1929). There is no evidence about experiments proving that regular cuttings before the heading stage of the Timothy really tend to diminish the frequency of flies, so that the advice must be considered more or less as a theory. However, it is probable that the measure may be effective after some years, especially in fields which are not surrounded by too much wild Timothy. At the State Experimental Farm Offer in Norrland the observation has in fact been made, that attacks by Timothy flies are now of smaller extent than formerly. This may possibly be due to the earlier harvesting of the grass (Ericsson and Skoog 1955).

Also deep ploughing of the attacked fields in the autumn is recommended (T. H. Schöyen 1914, Mühle 1953). But Mühle adds, that in spite of this measure being taken, one has to reckon with a certain number of flies emerging from pupae deeper down in the soil. There are, however, no experiments illustrating this statement. As may be seen from the experiments (p. 327) pupation takes place for most of the larvae in the upper layer of the soil (0—2,5 cm.), and consequently deep autumn ploughing ought to influence the emerging of the flies. By ploughing more isolated, severely infested older fields, it should be possible to lessen the danger of new infestations of new crops in the immediate neighbourhood. In areas with a more intensive seed production of Timothy, the measure would probably be of no importance against later attacks by Timothy flies, as the chances for new infestations are much too high, and the same must apply to fields surrounded by wild Timothy.

Further advice found in literature for the purpose of limiting attacks by Timothy flies is not to let the fields of Timothy become older than *two years* as the attacks on older fields were considered much the heaviest. The fact that this viewpoint does not generally hold good has been discussed above (p. 335).

The effect of *manuring* the grass as a measure against the attacks has been mentioned by BARNES, who observed that attacks by Timothy flies were lighter in manured fields than in fields without manure.

2. Experiments with chemical control of the flies

The writer's experiments have almost exclusively had in view the control of the adult flies before and during oviposition by means of chemicals. To succeed with treatments of this kind, it is naturally of the utmost importance — besides selecting the proper insecticide — to start application at a suitable time i. e. before the general oviposition has begun.

The experiments have been carried out in Timothy fields on organic soil during the years 1951—56. The moment of application was fixed every year on the basis of the results of nettings.

Among chemicals it was chiefly DDT that was tested, in some tests also mixed with MCPA herbicide. Further, parathion has been applied in two experiments and BHC in one.

In the first experiment (1951) the application was made by means of a hand-dusting method. However, it was soon evident that great areas had to be included, as otherwise surrounding, untreated Timothy fields would furnish too many flies ready for egg-laying, which would swarm over the treated areas and destroy the reliability of the experiments. The experiments were therefore carried out on a greater scale: about 0,4 hectare was the minimum area for the different plots.

The effect of the treatments has been examined by regular nettings, investigations into the number of eggs deposited (test 1955), and by an estimate of the damage to the ears in different parts of the test area. Generally 4 series of nettings have been executed during every netting-day per plot, each series comprising 25 sweeps.

As can be seen from the test results, *flavipes* has completely prevailed in the tests. On the other hand, a sufficiently large number of *armillatum* has been obtained, so that the results obtained are completely applicable also to this species.

The control nettings are shown here from test 2 in the form of diagrams. In these both species, *flavipes* and *armillatum,* have been put together. In practical experiments, as the ones treated here, there is no reason for separating them: both flies emerge simultaneously and the chemicals tested have the same effect on both species. But in some tests the effect on other *Diptera* has been included in special diagrams, partly because in some cases the number of these flies has been the largest, partly because the effect of insecticides on flies in general also gives us a clearer idea as to the effect in the field on Timothy flies.

When studying the following diagrams, (fig. 24, 25, 27, 29 and 33), the

influence of the weather on the netting-results should be kept in mind. This is most clearly seen in apparently unexplained variations in the curve of check: when the weather is steady, warm and sunny, the flies are very active and are caught in great numbers (the curve shows maximum); on cool, windy days the flies remain next to the ground and are not caught as easily (the curve shows minimum).

Test 1.

The test was conducted at the farm of St. Ståltorp on May 24th, 1951, in favourable weather.

Treatments:

a. DDT-dust, 1 application with 20 kg DDT-dust per hectare, on May 30th
b. „ 1 „ „ 20 „ „ „ „ on May 24th
c. „ 2 applications „ (2×20 kg) DDT-dust per hectare, on May 24th and 30th
d. Check

The DDT-material used held 5 % active ingredient.

The plots a, b, c were 40×30 m. in area. The check was about 40×120 m. (fig. 23). The DDT-dust was applied by hand-dusting method. Nettings were executed on May 30th and on June 1st and 6th. Only a comparatively small number of flies were captured, principally *flavipes*, viz. 13—14 flies per netting day of untreated plots and 1—0 flies from the treated ones.

The attack on the different plots was examined on July 3rd by counting

Fig. 21. Estimation of the degree of infestation in a control experiment.

Gradering av axangreppet i ett bekämpningsförsök mot timotejflugorna.

the damaged ears in certain square metre areas chosen at random from the plots (fig. 21).

Results July 3rd, 1951 (dam. ears=number of damaged ears, A=average number of damaged ears pr. sq. metre)

Treatment:	Number of attacked ears per m²									
plot no.	1	2	3	4	5	6	7	8	dam. ears	A
a. DDT 30/5	4	0	0	4	3	5	1	3	20	2.5
b. „ 24/5	1	1	1	2	2	2	1	2	12	1.5
c. „ „ and 30/5	0	0	4	2	0	2	2	0	10	1.3
d. Check I	4	4	1	7	6	1	6	6	90	6.0
II	1	4	23	4	11	8	4			

The total amount (damaged and undamaged) of Timothy ears per sq.-metre of the field varied between about 220 and 440 (average from 4 m² =304). As can be seen the attack was slight and of no economic importance.

The DDT-treatments seem to have given good results in these experiments. Treatment c (2 applications) seems the most effective but the difference between this one and b (an earlier treatment) is very small and almost unperceptible.

Test 2.

The test was carried out at the farm of Trestena in 1952. The treatment was applied on May 17th in very favourable weather by means of a tractor-driven sprayer, equipped with 3 nozzles[1] (fig. 22).

[1] In Sweden named Håte nozzles.

Fig. 22. The sprayer in action in test 2.

Besprutningen utförs i försök 2.

Treatment:	*Dosage per hectare:*
a. DDT	2.4 litres of emulsion with 25 % active ingredient
b. Parathion	0.5 „ „ „ „ 35 % „ „
c. Check	

The sprayer delivered 400 litres of spray mixture per hectare.

The design of the test is seen from fig. 23. As shown, plot a and b were both about 0.5 hectare. The test was examined by nettings. The weather was generally sunny, but cool and windy, which resulted in a low number of Timothy flies.

As seen from fig. 24 no Timothy flies from DDT-sprayed areas were captured and only one fly per sweep from parathion-sprayed plots. The number of Timothy flies from the untreated (check) areas is small, but quite different from the others. Because of the low number of flies in the test field, it may be considered that only very few flies flew into the field from the neighbourhood, and the result may have been that the parathion-spraying, especially according to the first diagram, shows a better residual effect than was really obtained. In the latter diagram (other *Diptera*) a result is shown which must be deemed to be more in agreement with reality.

On July 3rd the attack by Timothy flies was estimated by counting 10 randomly picked one square metre quadrangles of the plots treated, and 20 one square metre quadrangles of untreated plot.

Results: (A = average number of damaged ears per square metre):

Treatment:	Number of attacked ears per sq. metre												
plot no.	1	2	3	4	5	6	7	8	9	10	Total	A	
a. DDT	1	0	3	0	3	1	2	1	3	0	14	1.4	
b. Parathion	11	8	11	21	12	11	10	10	12	7	113	11.3	
c. Check	9	5	13	8	8	9	12	11	9	16	100	10.0	11.3
d. „	7	22	9	15	14	15	14	5	16	9	126	12.6	

As may be seen from the above, the DDT-spraying has been very effective. In an area of 10 square metres only 14 damaged ears, that is 1.4 damaged ear per square metre, were found, as compared with 11.3 damaged ears per square metre of untreated and parathion-sprayed plots.

Test 3.

The test was carried out on the same property as test 2 (Trestena) but a year later, and in another Timothy field. The spraying was applied on May 11th, (1953) in very favourable weather, by means of a tractor-driven sprayer equipped with Håte-nozzles at the rate of 330 litres per hectare.

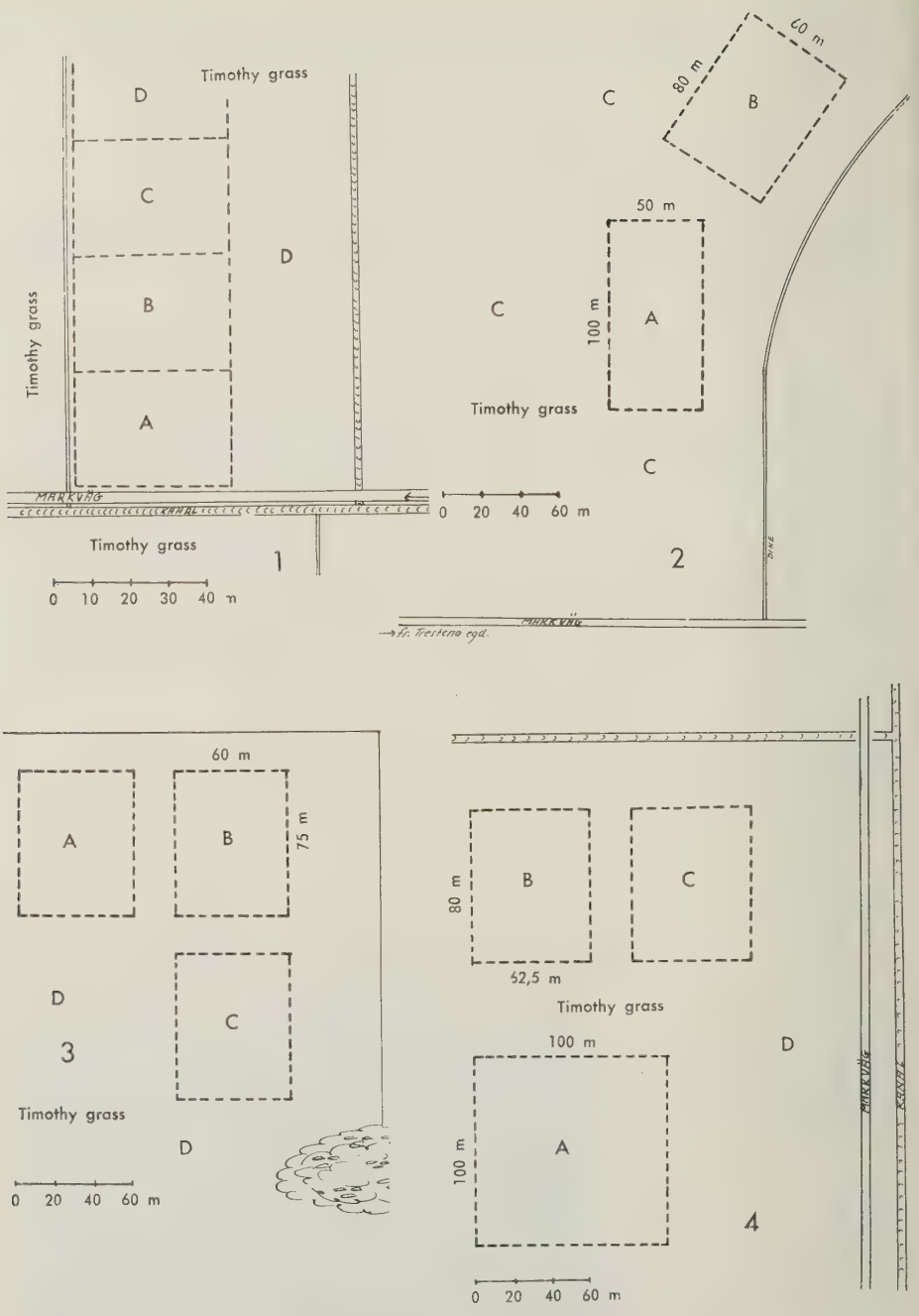

Fig. 23. The design of test 1—4.
Planskiss över försöken 1—4.

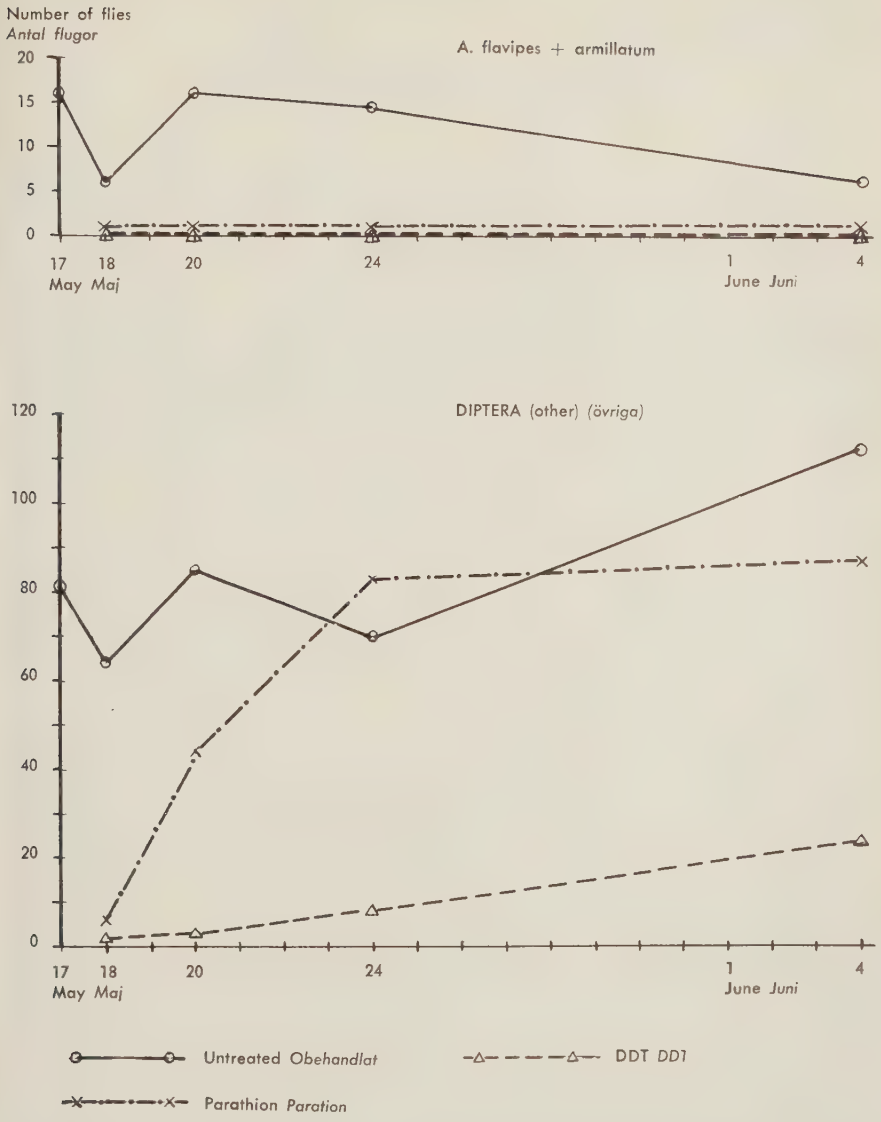

Fig. 24. Test 2: the effect of the treatments on the flypopulation according to nettings. 100 (4×25) sweeps.

Försök 2: effekten av bekämpningarna enligt frekvenshåvningar. 100 håvslag.

Treatment:	*Dosage per hectare:*
a. Parathion	0.4 litres of emulsion with 45 % active ingredient
b. DDT	3.5 „ „ „ „ 20 % „ „
c. DDT + MCPA	3.5 „ „ „ „ 20 % „ „ (DDT) + 14 litres MCPA (Agroxon)
d. Check	

The design of the test is given in fig. 23. Each of the test areas was 4,500 square metres. The nettings in untreated Timothy grass were done preferably in the unsprayed area next to plots a and c.

As shown in fig. 25, the sprayings were very effective against Timothy grass flies. In the first 3 netting days (May 18th incl.) the maximum was two Timothy flies in a hundred sweeps per treated plot. The effect of DDT in treatment c had not been reduced through mixture with the herbicide Agroxon (MCPA). After May 18th very few flies were captured in the test, mostly because no greater flight could take place as the flight was then declining, and this is also seen from fig. 13 (nettings at Dagsnäs). The weather also grew less favourable towards the end of the flight. As shown in the lower diagram (fig. 25), other *Diptera,* the frequency here is similar to the one mentioned before. The residual effect of the insecticides, however, is shown more correctly, as a fuller flight had been possible because a number of species may be counted amongst "other *Diptera*". As may be seen, no effect of the parathion-spraying is visible on the flies after seven days (May 18th). But the DDT-sprayings were still effective on the last netting day, that is 17 days after application.

The attack by Timothy grass flies was evaluated on June 18th. On ten randomly picked one square metre quadrangles per plot, the number of damaged Timothy ears was counted. To get an evaluation of the density of the Timothy grass in the field, the total number of ears (damaged and undamaged) were counted in two areas of each one square metre. By this, an average of 544 per square metre was obtained.

The degree of infestation was (A = average number of damaged ears per square metre):

Treatment:	Number of attacked ears per square metre											
plot no.	1	2	3	4	5	6	7	8	9	10	Total	A
a. Parathion	4	4	3	5	1	2	2	3	1	2	27	2.7
b. DDT	0	0	1	0	2	2	1	0	1	0	7	0.7
c. DDT + MCPA	0	1	1	0	0	0	0	1	1	0	4	0.4
d. Check	10	9	12	11	12	11	17	11	15	10	118	11.8

As may be seen, the infestation of untreated areas was of no economic importance: the average value of 11.8 damaged ears per square metre is equivalent to a 2 % attack. This fact, however, does not tend to lessen the

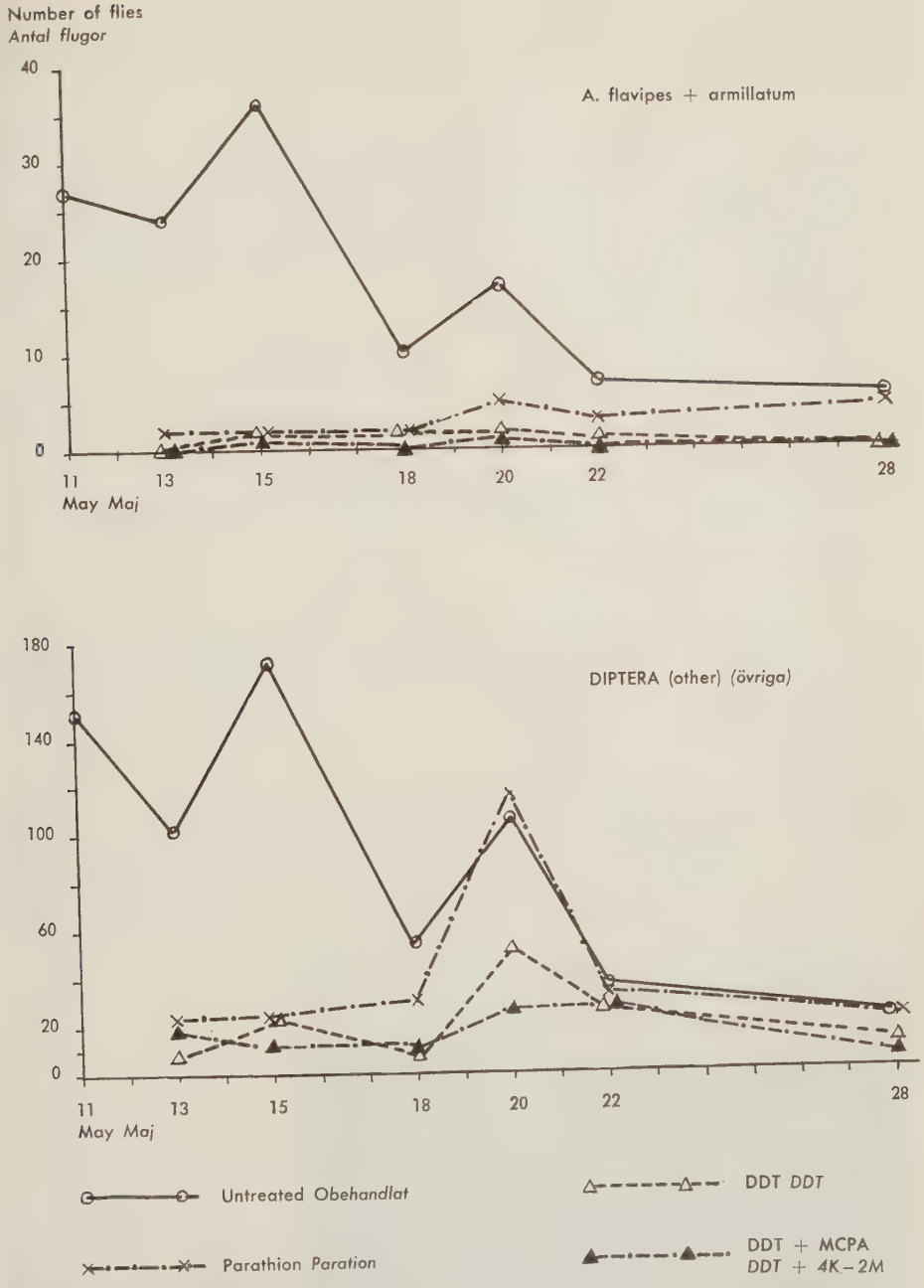

Fig. 25. Test 3: the effect of the treatments on the flypopulation according to nettings. 100 sweeps.

Försök 3: effekten av bekämpningarna enligt frekvenshåvningar. 100 håvslag.

value of the test, as all treatments resulted in a significant effect. DDT + MCPA and DDT alone were most effective.

Test 4.

The test was conducted in an older Timothy grass field at the farm of Dagsnäs in 1954. DDT and DDT + MCPA herbicide (Agroxon) were used for spraying in this test and DDT for airplane dusting. The spraying was done by a tractor-driven sprayer. The plan was to carry out the applications simultaneously, but because of steady rain the sprayings were carried out much later than the airplane dusting.

Treatment:	*Dosage per hectare:*
a. DDT (airplane dusting 17/5):	15 kg of dust with 5 % active ingredient.
b. DDT (spraying 24/5):	2.4 litres of emulsion with 18 % active ingredient.
c. DDT + MCPA (spraying 24/5):	2.4 litres of emulsion with 18 % active ingredient (DDT) + MCPA.
d. Check	

The sprayer delivered 320 litres of spray mixture per hectare. The airplane dusting was carried out on May 17th in the evening, in favourable weather (fig. 26) and the spraying on May 24th. The plan of the test is shown in fig. 23. As shown, the dusted area covered 1 hectare and the sprayed ones each 0.5 hectare.

The first few flies were captured on May 10th in nettings in a Timothy grass field next to the test field, and from May 14th onwards a greater number was caught. As may be seen from nettings on May 17th, the flies were then caught in great numbers (fig. 27). Two days later nettings were carried out in unfavourable weather and the curves of the diagram show

Fig. 26. The airplane dusting in test 4 was carried out on a calm evening by a Piper Cub.

Flygbepudringen i försök 4 utfördes en lugn kväll med en Piper Cub.

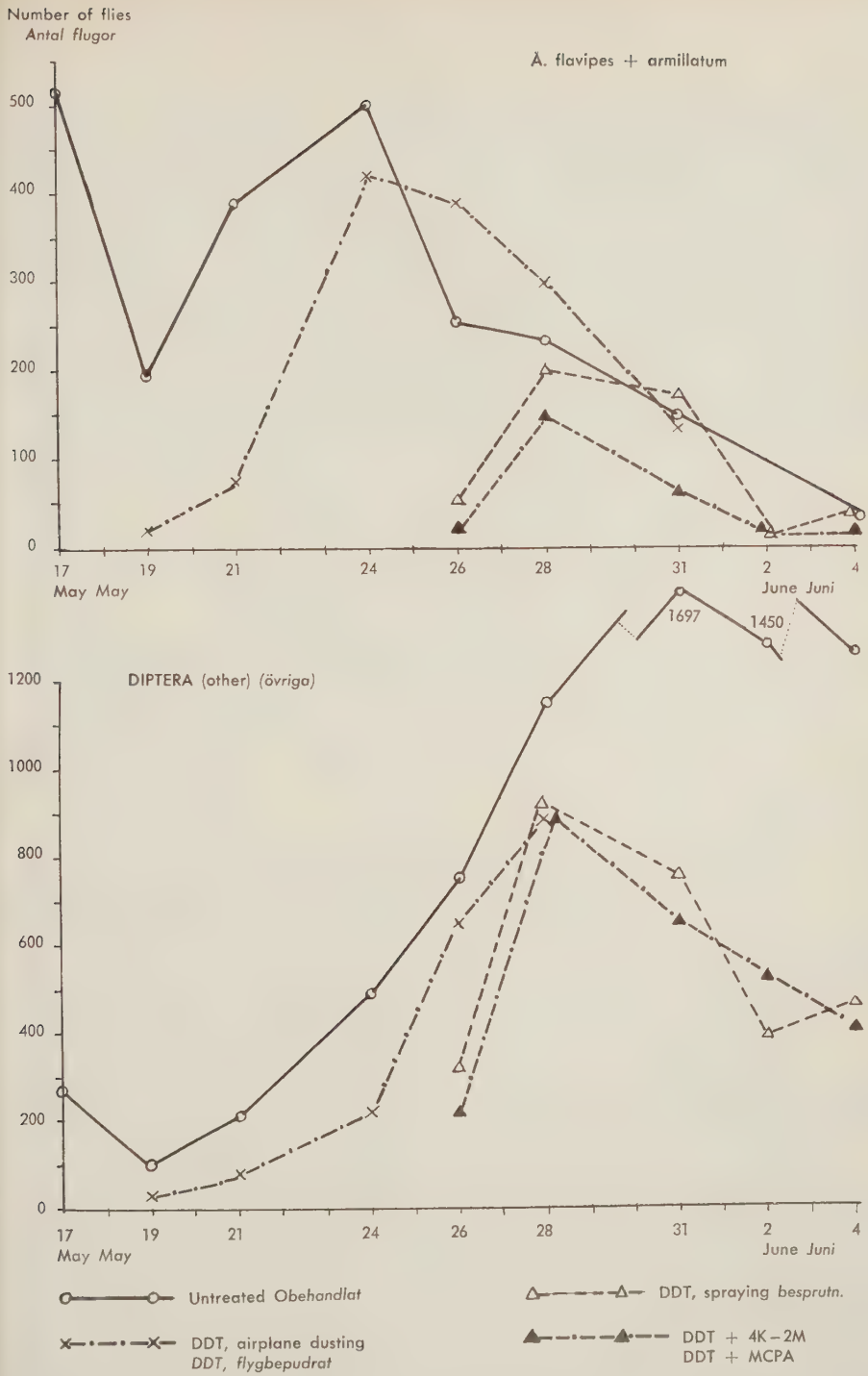

Fig. 27. Test 4: the effect of the treatments on the flypopulation according to nettings. 100 sweeps.

Försök 4: effekten av bekämpningarna enligt frekvenshåvningar. 100 håvslag.

a minimum. The effect of the DDT-dusting shows distinctly right to the seventh day after the treatment, but no longer. The residual effect was reduced quickly between 4th and 7th day after the application, as may be seen from the diagram. Without doubt, the rain had had a detrimental effect on the result. As already mentioned, the sprayings could not be carried out because of the rain until May 24th. Nettings two days later showed the effect to be good, but after four days it was unsatisfactory. The cause may have been partly that the DDT-material was underdosed, partly that the weather after the spraying became too rainy.

The degree of infestation was checked on July 6th. The attack as a whole was very severe on the organic soils near the Hornborga lake, which was to be expected when the great number of flies found earlier is considered. The number of damaged and undamaged ears of Timothy grass was calculated in half-square metre areas picked at random.

As shown in table 8, no practical control was obtained by means of the

Table 8. Test 4. The degree of infestation estimated July 1954.

Tabell 8. Försök 4. Axangreppet avräknat juli 1954.

Treatment *Försöksled*	No. ears per ½ sq. metre Antal timotejax per ½ m²						Total *Summa*	Per Cent Infest. *% angrepp*	Average no. dam. ears per ½ sq. metre *Medeltal angr. ax per ½ m²*
	1	2	3	4	5	6			
a. DDT, airplane dusting *flygbepudring*									
damaged *angripna*	101	110	144	104	102		561	58.4	112.2
not damaged *ej angripna*	102	82	115	48	53		400		
b. DDT, spraying *besprutning*									
damaged *angripna*	91	72	119	93	39		414	47.8	82.8
not damaged *ej angripna*	96	126	96	91	43		452		
c. DDT+MCPA, spraying *besprutning*									
damaged *angripna*	60	58	54	37	49		258	29.3	51.6
not damaged *ej angripna*	112	173	99	140	100		624		
d. Untreated *Obehandlat*									
damaged *angripna*	164	152	105	119	155	120	815	62.5	135.8
not damaged *ej angripna*	83	69	112	61	39	124	488		

different treatments. The best result was found in plot c, where the infestation was reduced to one half. In spite of the spraying, the infestation, however, was much too severe (29.3 %). The airplane dusting proved completely ineffective. If the number of flies is studied according to fig. 27, one might tend to believe that the airplane dusting has been by far the most effective, and should therefore have given the best control, and not the opposite, as was the case. This can be explained by the fact that while the DDT dusting was effective, the greater part of the flies were not egg mature. From the moment when the eggs were mature, the dusting had no effect and a great deal of flight activity over the plots took place, whereas the sprayings, on the contrary, were effective on the flies when these were egg-mature.

Test 5.

The test took place at the Dagsnäs farm in 1955. Spring was unusally late that year, and the applications were not carried out until the end of May.

Treatment: *Dosage per hectare:*

a. DDT (airplane dusting): 20 kg of dust with 5 % active ingredient
b. DDT (spraying): 4 litres of emulsion „ 20 % „ „
c. BHC (spraying): 4 „ „ „ „ 17 % „ „
(6.25 % gamma)

d. 1st check
d. 2nd check

The sprays were applied with a tractor-driven sprayer[1] delivering 300 litres of spray mixture per hectare.

The arrangements of the test is seen from fig. 28. The DDT-dusted area was 3.0 ha., the DDT-sprayed one about 1.8 ha. and the BHC-sprayed one about 1.0 ha. The materials were applied on May 27th in very favourable weather (sunny, warm, quiet). As may be seen from the curve of the untreated plot in the diagram, Timothy flies were very numerous in the test field this day, which was the first day of the year when the warm weather had brought the flies out in great quantities. A warm and dry spell of weather followed after the applications and this was very favourable for the residual effect of the treatments.

When the population of flies is studied in the treated plots after the applications, as seen in fig. 29, it may clearly be seen that the applications in general have lessened the number of flies considerably on treated plots as compared to untreated ones. The best effect was obtained by the DDT sprayings: the number of captured flies varied between 0 (8/6) and 22 (3/6). The corresponding numbers for untreated plots were 28 (17/6) and 755 (30/5). The rest of the result of the nettings may be seen from table 9.

[1] In Sweden called Moteska-sprayer.

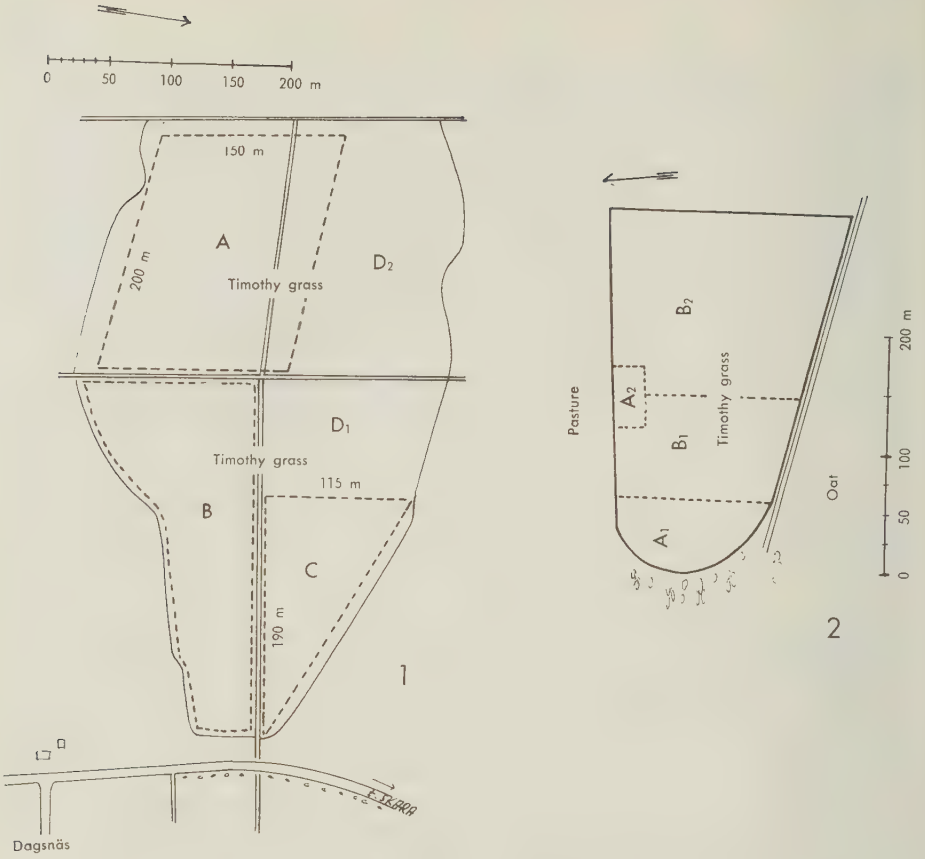

Fig. 28. The design of test 5 and 6.
Planskiss över försök 5 och 6.

Table 9. Number of flies caught by nettings (4×25 = 100 sweeps), test 5.

Tabell 9. Antal timotejflugor erhållna vid frekvenshåvningar (4×25 = 100 slag), försök 5.

Treatment *Försöksled*	Netting days *Håvningsdagar*										Total *Summa*
	28/5	30/5	1/6	3/6	6/6	8/6	10/6	14/6	17/6	20/6	
a. DDT, airplane dusting *flygbepudring*	31	26	38	77	12	9	20	31	7	36	287
	172				115						
b. DDT, spraying *besprutning*	15	6	8	22	11	0	4	13	5	11	95
	51				44						
c. BHC, spraying *besprutning*	16	102	25	71	46	46	67	72	27	46	518
	214				304						
d. Untreated *Obehandlat*	532	755	385	228	93	101	88	88	28	33	2 331
	1 900				431						

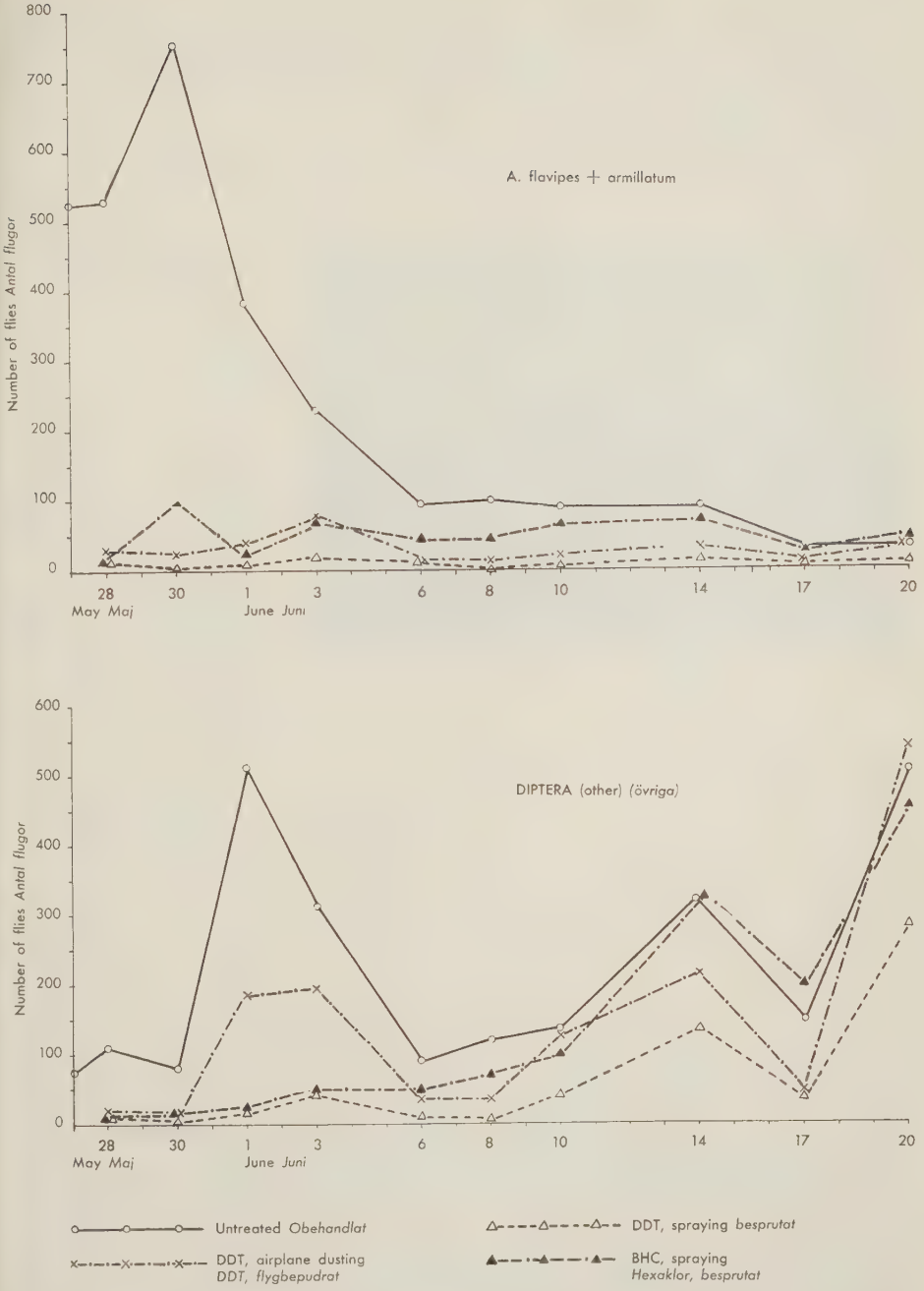

Fig. 29. Test 5: the effect of the treatments on the flypopulation according to nettings. 100 sweeps.

Försök 5: effekten av bekämpningarna enligt frekvenshåvningar. 100 håvslag.

In one case the effect of the treatments on the number of eggs laid in the Timothy field was evaluated. On 7th of June, 50 Timothy plants were collected from each test plot. The number of eggs per plant was counted in the laboratory.

Fig. 30. The airplane dusting in test 5 was carried out during the day by a Piper Cub.

Flygbepudringen i försök 5 utfördes under dagen vid gynnsamt väder med en Piper Cub.

Result:

Treatment:	no. of eggs pr 50 plants 7/6:	no. of plants with eggs:
a. DDT, airplane dusting:	17	15
b. DDT, spraying:	4	4
c. BHC, spraying:	82	43
d. Check:	94	42

As has been said in earlier chapters generally only one egg is laid on each Timothy plant. Exceptions mostly occur in years with a profuse number of flies. As shown above, somewhat more than 2 eggs had been laid on each plant in an average of untreated areas. In 2 cases 6 eggs per plant were observed. As already mentioned the explanation is to be found in the very great number of flies in 1955.

The attack was estimated on 4th and 5th of July through counting the number of damaged and undamaged ears in randomly picked check areas of one square metre. The result is shown in table 10.

Table 10. Test 5. The degree of infestation estimated July 1955.

Tabell 10. Försök 5. Axangreppet, avräknat juli 1955.

Treatment *Försöksled*		No. ears per sq. metre *Antal timotejax per m²*					Total *Summa*	Per Cent infest. *% angr.*	No. dam. ears per sq. metre *Antal angr. ax pr m²*
		1	2	3	4	5			
a. DDT, airplane dusting *flygbepudring*									
I	damaged *angripna*	13	12	28	31	20	104	5.6	
	not damaged *ej angripna*	382	376	375	350	285	1 768		
II	damaged *angripna*	30	43	34	25	25	157	8.4	
	not damaged *ej angripna*	261	394	324	374	353	1 706		
III	damaged *angripna*	29	23	43	23	46	164	8.1	
	not damaged *ej angripna*	402	392	437	297	340	1 868		
Total: *Summa:*	damaged *angripna*						425	7.4	28.3
	not damaged *ej angripna*						5 342		
b. DDT, Spraying *besprutning*									
I	damaged *angripna*	22	7	4	24	9	66	4.8	
	not damaged *ej angripna*	265	328	280	208	227	1 308		
II	damaged *angripna*	10	7	3	7	6	33	2.1	
	not damaged *ej angripna*	369	264	248	289	364	1 534		
III	damaged *angripna*	6	14	7	10	4	41	2.5	
	not damaged *ej angripna*	277	313	406	359	217	1 572		
Total: *Summa:*	damaged *angripna*						140	3.1	9.3
	not damaged *ej angripna*						4 414		

Treatment *Försöksled*			No. ears per sq. metre *Antal timotejax per m²*					Total *Summa*	Per Cent infest. *% angr.*	No. dam. ears per sq. metre *Antal angr. ax pr m²*
			1	2	3	4	5			
c. BHC, spraying *besprutning*										
	I	damaged *angripna*	77	77	83	88	96	421	33.9	
		not damaged *ej angripna*	178	130	149	178	186	821		
	II	damaged *angripna*	91	76	75	95	62	399	30.6	
		not damaged *ej angripna*	203	187	153	139	223	905		
Total: *Summa:*		damaged *angripna*						820	32.2	82.0
		not damaged *ej angripna*						1 726		
d:1 Untreated *Obehandlat*										
	I	damaged *angripna*	67	84	63	37	92	343	35.8	
		not damaged *ej angripna*	140	147	112	77	139	615		
	II	damaged *angripna*	56	67	59	46	59	287	32.5	
		not damaged *ej angripna*	153	149	125	79	89	595		
Total: *Summa:*		damaged *angripna*						630	34.2	63.0
		not damaged *ej angripna*						1 210		
d:2 Untreated *Obehandlat*										
	I	damaged *angripna*	78	81	96	103	117	475	27.3	
		not damaged *ej angripna*	290	167	213	308	284	1 262		
	II	damaged *angripna*	85	93	99	114	45	436	28.5	
		not damaged *ej angripna*	228	239	296	255	74	1 092		
Total: *Summa:*		damaged *angripna*						911	27.9	91.1
		not damaged *ej angripna*						2 354		

The DDT spraying has been most effective in the test (3.1 % attacked; 9.3 damaged ears per m^2) and the result is very reliable from a practical stand-point. The airplane dusting with DDT has reduced the attack effectively (7.4 % attacked against about 30 % in untreated). It must be noted that the dosage, of 20 kg per ha., is about double the one generally used in airplane dustings in Sweden, and further, that the weather during the dusting and also immediately after was very favourable. The spraying with BHC had no effect; this was already pointed out when the number of eggs was checked. When the results of the nettings are studied (fig. 29), the impression is, that the spraying with BHC should have been satisfactory as the number of flies captured up to 3rd June was considerably lower in the treated plot than in the untreated. The spraying with BHC was, however, most effective during a period when the flies in general were not egg mature. From around June 6th the residual effect of the spraying with BHC grows more and more unsatisfactory (see table 9). Further, the area sprayed with BHC was situated less favourably than the others since a relatively great number of egg-mature females could fly in over it from the nearby untreated area (field to the right on the sketch).

Test 6.

The experiment was conducted in a two year old seed crop of Timothy of the Omnia variety, sown in rows in organic soil at Broddetorp near Skara. Serious damage from Timothy flies was to be expected in the field, as similar damage had been observed the previous year (44 % infestation). The aim of the test was to apply fully and practically, all conclusions arrived at in earlier tests. Only spraying with DDT was tested.

Fig. 31. The sprayer in action in test 6.

Besprutningen utförs i försök 6.

Fig. 32. The sprayer is being filled (test 6).

Sprutan fylles på — försök 6.

Treatment:	*Dosage per hectare:*
A—1 untreated	
A—2 „	
B—1 DDT (spraying):	4 litres of emulsion with 20 % active ingredient
B—2 DDT (spraying):	3.6 litres of emulsion with 20 % active ingredient

The sprays were applied on May 19th with a tractor-driven sprayer delivering 200 and 185 litres of spray mixture per hectare in areas B-1 and B-2 respectively (fig. 28 and 31).

Further details about the arrangement of the test are shown in fig. 28. Plot B-1 amounted to 1 ha. and B-2 to 2.7 ha. of the areas treated.

The weather during the treatments and the time following was very favourable, dry and warm. The day of the spraying was the very first on which Timothy flies had been flying profusely over the fields. As may be seen from fig. 33, a great number of flies was obtained on the very day (May 19th). In the emergence boxes at Skara (fig. 10), the very first flies were seen on May 20th, whereas the first flies netted at Dagsnäs in a field with the same type of soil as the one where the spraying took place, were captured on May 15th, as seen in fig. 15. Oviposition in the field was observed on May 24th.

The number of flies in the areas treated decreased strongly after the spraying, as shown in fig. 33. The number of flies caught during the period 19th to 26th of May was, in DDT sprayed areas from 2 (26/5) to 21 (22/5), compared to 62 (26/5) to 508 (19/5) in untreated areas. From May 29th the number was so low even in untreated areas, that no flight could be observed in the test field after this date. As may be seen in fig. 15 regarding nettings at Dagsnäs, the flight was over here too about 1st of June (1956).

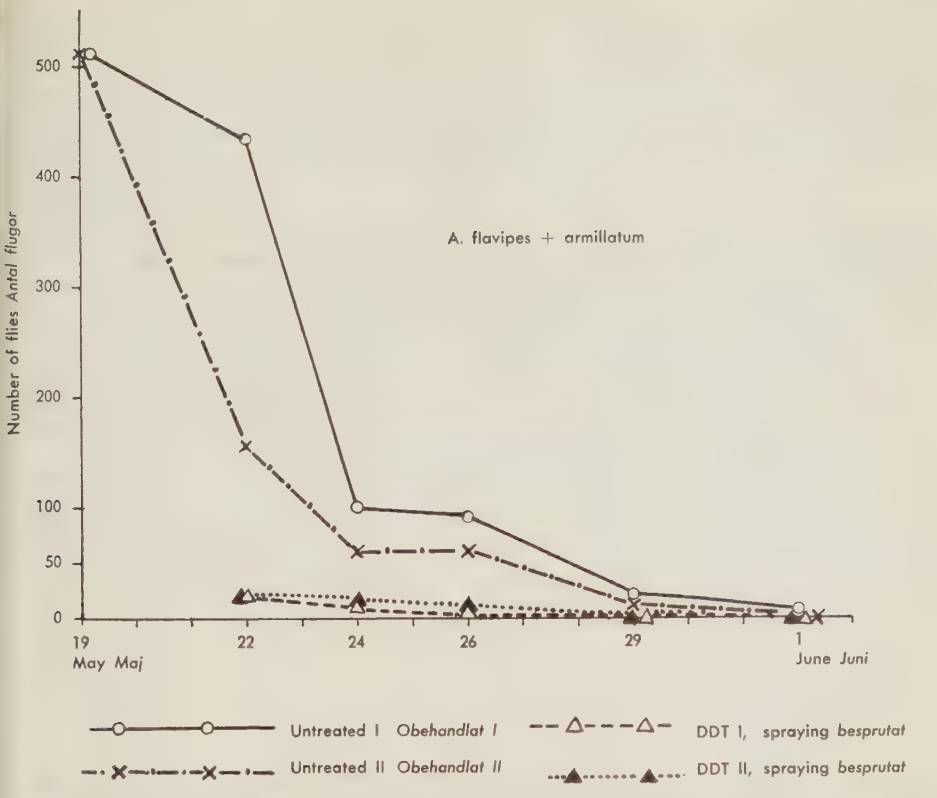

Fig. 33. Test 6: the effect of the treatments on the flypopulation according to nettings. 100 sweeps.

Försök 6: effekten av bekämpningen enligt frekvenshåvningar. 100 håvslag.

After the treatment, the ratio of flight was less in the small untreated area A-2 than in the larger untreated area A-1, which was to be expected, as A-2 was relatively small compared to the other test fields, and, further, it was surrounded on three sides by treated areas: the flies occurring at the start in the said untreated area very easily moved into the plots treated.

The degree of infestation was checked on 7th and 8th of August as in earlier tests, i. e. counting the number of damaged and undamaged ears in randomly picked areas of a square metre. The result is seen in table 11. The infestation of the DDT sprayed areas must principally be compared with the infestation of the larger untreated area, A-1. As may be seen, the infestation in the sprayed areas had an average percentage of 0.8 with 4.1 damaged ears per m^2 compared to 11.4 % and 64.5 damaged ears per m^2 of untreated area. The difference between infestation of treated plots and the smaller untreated one A-2 is less than in the first case, the attack, however, was reduced significantly here also.

Table 11. Test 6. The degree of infestation estimated August 1956.

Tabell 11. Bekämpningsförsök 6. Axangrepp avräknat i augusti 1956.

Treatment *Försöksled*			No. ears per sq. metre *Antal timotejax per m²*					Total *Summa*	Per Cent infest. *% angr.*	No. dam. ears per sq. metre *Antal angr. ax pr m²*
			1	2	3	4	5			
Untreated *Obehandlat* A-1	I	damaged *angripna*	47	63	67	68	87	332	12.4	66.4
		not damaged *ej angripna*	446	436	526	440	498	2 346		
	II	damaged *angripna*	70	44	52	79	68	313	10.5	62.6
		not damaged *ej angripna*	540	448	504	596	586	2 674		
Total: *Summa:*		damaged *angripna*						645	11.4	64.5
		not damaged *ej angripna*						5 020		
Untreated *Obehandlat* A-2		damaged *angripna*	31	36	22	29	15	133	5.4	26.6
		not damaged *ej angripna*	512	464	388	494	462	2 320		
DDT, spraying *besprutning* B-1	I	damaged *angripna*	3	6	6	2	7	24	0.9	4.8
		not damaged *ej angripna*	436	636	584	610	532	2 798		
	II	damaged *angripna*	8	1	4	8	2	23	0.8	4.6
		not damaged *ej angripna*	716	520	616	552	504	2 908		
B-2		damaged *angripna*	0	2	1	6	5	14	0.6	2.8
		not damaged *ej angripna*	392	396	436	480	450	2 154		
Total: *Summa:*		damaged *angripna*						61	0.8	4.1
		not damaged *ej angripna*						7 860		

3. Other control methods

Among other methods for the control of Timothy flies in seed crops which have not already been referred to here, experiments with repellents must be mentioned. King, Meikle and Broadfoot thus state that promising results have been obtained with an emulsion of crude naphtalene in peanut oil.

Because of severe infestations by Timothy flies and of rainy periods, a field with Timothy seed on a farm some miles from Skara was not harvested during the autumn 1954. In the following spring, the dry Timothy grass was burnt. To investigate if the burning had any injurious effect to the hibernating puparia in the soil, 5 emergence boxes (each with a surface of 30×30 cm.) were placed in the burnt field, and 5 similar boxes in the nearby field where the grass had not been burnt. Between May 21st and June 14th, forty-three Timothy flies were obtained (*flavipes* and *armillatum*) in the emergence boxes in the burnt soil, and twenty-nine in the field where the grass had not been burnt. This result shows that one cannot expect any especially high mortality among pupae of Timothy grass flies by burning the grass during the spring.

VII. Discussion on the control experiments

Insecticides and dosage: In the control experiments described in chapter VI, spraying and dusting with DDT has been tested as well as spraying with parathion and BHC. The experiments have been reviewed in table 12. The best effect was obtained by *spraying with DDT*, which resulted

Table 12. Abstract of control experiments against Timothy flies.

Tabell 12. Sammanfattning av bekämpningsförsök mot timotejflugorna.

D = Hand dusting (*bepudring*); AD = Airplane dusting (*flygbepudring*); S = Spraying (*besprutning*).

Test, year Insecticide *Försök, år Medel*	Application *Behandling*	Dosage *Dosering*		Degree of Infestation *Angrepp*			
				Untreated *Obehandlat*		Treated *Behandlat*	
		Grams Actual/Ha *Effektiv substans g/ha* (approx.)	Spray mixtures Litres/Ha *Vätskemängd lit./ha* (approx.)	No. Damaged Ears per sq. metre *Antal skadade ax per m²*	Per Cent *Procent*	No. Damaged Ears per sq. metre *Antal skadade ax per m²*	Per Cent *Procent*
1 —1951							
DDT	D 24/5	1 000				1.5	
DDT	D 30/5	1 000		6.0		2.5	
DDT	D 24/5+30/5	2×1 000				1.3	
2 — 1952							
DDT	S 17/5	600	400			1.4	
Parathion	S 17/5	175	400	11.3		11.3	
3 — 1953							
DDT	S 11/5	700	330			0.7	
DDT+MCPA	S 11/5	700	330	11.8		0.4	
Parathion	S 11/5	180	330			2.7	
4 — 1954							
DDT	AD 17/5	750				224.4	58.4
DDT	S 24/5	430	320	271.6	62.5	165.6	47.8
DDT+MCPA	S 24/5	430	320			103.2	29.3
5 — 1955							
DDT	AD 27/5	1 000				28.3	7.4
DDT	S 27/5	800	300	63.0	34.2	9.3	3.1
BHC	S 27/5	42.5 γ	300	91.1	27.9	82.0	32.2
6 — 1956							
DDT	S 19/5	800	200	64.5	11.4	4.1	0.8
DDT	S 19/5	700	185				

in good commercial control. In the five experiments where DDT was used, good control was obtained in four tests. In the fifth (test no. 4), the DDT spraying gave no practical control. This may very well be due to underdosing of the insecticide and also to the fact that the spraying was started some days too late because of unfavourable weather. Around the test field were extensive Timothy grass fields with an exceptionally profuse occurrence of Timothy flies. From these fields flights occurred and this also augmented the unsatisfactory result of test 4. *Dusting with DDT* resulted in good control in two tests. In a third test (no. 4) no positive effect was obtained, probably because of very unfavourable weather: on the day after the application, which took place in the evening, there was a precipitation of 10 mm of rain and on each of the following five days after it rained again, in all about 25 mm.

Spraying with DDT is at present the method which must be recommended foremost in chemical control of Timothy grass flies. The dosage can be termed "normal". In the tests about 600—800 gr. actual DDT per hectare have been applied, that is 3—4 litres of e. g. a DDT emulsion with 20 % active ingredient. In the tests, the amount of the liquid has been varied from 400 to 185 litres per hectare, but it has not been possible to find that this variation of quantity of spray mixture has had any significant effect on the results. A DDT spraying on Timothy grass in favourable weather has a visible residual effect lasting approximately a fortnight, sometimes somewhat longer. In two tests the DDT material was mixed with MCPA herbicide without the effect being reduced.

Spraying with parathion (175—180 gr. actual toxicant per hectare) has given less effective control than spraying with DDT. It gave a residual effect in Timothy grass of about 6 days. As there are often pastures around Timothy fields for seed production, parathion is less suitable because of its great toxicity.

BHC (42.5 gr. gamma—BHC per hectare) was applied only in one test and with completely ineffective result.

The time for chemical control: The sprayings with DDT are intended to destroy the Timothy flies before the actual oviposition. It is therefore of vital importance for effective control that the treatment takes place at the right moment. The best results are obtained when the application takes place as close to the oviposition as possible.

As may be seen from the preceding text, the main emergence of adult flies takes place during a comparatively short period, in Central Sweden generally during one week in May. The females are egg-mature only after about eight days. This gives a certain time margin to decide the best moment for the control. Chemical control of Timothy flies is not necessary every year in one and the same crop. The flies tend to occur periodically (see chapter V). Especially during the first year after an infestation, the

farmers must be prepared for new attacks. If chemical control is needed, the flies occur in such masses in the Timothy grass that they are easily seen, especially on warm, sunny, calm days. The flies often rest on the plants, head down and wings folded across the abdomen. At Skara, (Central Sweden) the best time for control during the years 1951—56 was between 11th and 27th of May (see table 12). When the spring comes early, control must be carried out at the beginning of this period, when late, towards the end of the period.

In order to be able to fix the time of chemical control of the flies, or the beginning of their flight, experiments to this end have been carried out through observing the development of the vegetation. Timothy grass in Sweden is not generally at such a stage of growth by the middle of May to serve as guidance. Even regarding some other observed plants, the uncertainty is far too great to allow a more exact fixation of the time of control according to the stage of their development. Possibly, the approximate development of some particular plants at the moment when a DDT control is called for would be of a certain value. Thus, the colts-foot (*Tussilago farfara*) has generally ceased flowering, dandelion (*Taraxacum vulgare*) is flowering as is also the cherry tree (*Prunus cerasus*) if it does not grow in especially late habitat. At the time best suited for control, the common birch (*Betula alba*) has generally started to come into leaf and these have often reached a size of about 1 cm.

Through observations of the development of the vegetation, it would, however, only be possible to determine the time of chemical control approximately. To fix the time of application more exactly it is necessary to observe the time when the Timothy flies first begin to fly.

Summary

I. Among flies denominated Timothy flies, literature mentions *Amaurosoma armillatum* Zett. and *A. flavipes* Fall. as appearing in a number of European countries and a related species *Trichopalpus* (*Chaetosa*) *punctipes* Meig. in inter alia France.

Synonyms:

Amaurosoma armillatum Zett.
Cordylura armillata Zett.
Cleigastra armillata Zett. (Schin.)
Cnemopogon obscura var. 2 (*armillata*) Pandellé.

Amaurosoma flavipes Fall.
Cordylura flavipes Fall.
Cordylura frontalis Macq.
Cleigastra flavipes Schin.
Cnemopogon flavipes var. 1 Pandellé.

Trichopalpus punctipes Meig.
Chaetosa punctipes Mall.
Cleigastra punctipes Macq.
Cleigastra flavipes Meig.

The Swedish entomologist Lampa (1893) proved that the larvae of *A. armillatum* Zett. are pests in Timothy grass. Earlier statements as regards the biology of *A. flavipes* Fall. are rather unreliable since distinction between *flavipes* Fall. and *flavipes* Meig. has not always been made. Thus, Lindeman (1887) describes the biology of a Timothy grass fly which he identified as *Cleigastra flavipes* Meig. His description of the fly shows plainly that it was not *Cleigastra flavipes* Meig. (= *Trichopalpus punctipes* Meig.) but some other species, possibly *A. armillatum* (see p. 302). In literature it is not possible to find any conclusive proof that the larvae of *T. punctipes* live in Timothy grass ears.

A. flavipes Fall. has Timothy grass (*Phleum pratense*) as its natural host plant. In some systematic papers (Séguy 1934, Sack 1937) *Euphorbia* is also mentioned as the host plant for the species, but this is probably due to a misunderstanding (see p. 303). To sum up, it may be said that in the family *Cordyluridae* (*Scatophagidae*) only *A. flavipes* Fall. and *armillatum* Zett. with certainty have been hatched from larvae collected on damaged ears of Timothy grass.

II. Imago, egg, larva and puparium of the two species are described.

III. The Timothy flies *armillatum* and *flavipes* Fall. are mainly known from Europe. In Sweden the two species occur over the whole country (fig. 6).

From rearing flies from larvae collected in Timothy grass in different habitats, and from nettings in Timothy in mineral soils and in organic soils it is proved, that in Central Sweden *armillatum* is the prevailing species in mineral soils, and *flavipes* Fall. in organic soils.

IV. In order to find out the period when the flies emerge from the pupae, larvae were collected when the seed heads of the Timothy grass appeared. The larvae were placed outdoors to emerge under natural conditions. The emergence period over six years (1950—56) is given in fig. 8—10. As shown, the emergence in Central Sweden takes place over a relatively short time in May, (in some warm springs from the end of April): within a ten-day period most flies have emerged. The two species emerge during the same period. The males prevail at the beginning of the period and the females toward the end. Males and females are to be found in about the same numbers. As shown (table 2), 50.9 % were females out of 163 *armillatum* and 57.2 % out of 493 *flavipes*, all emerged from collected larvae. Out of a total of 971 *armillatum* caught by nettings, 49.6 % were female, as were 56.2 % out of a total of 6 463 *flavipes* (table 3).

The flies are seen in the Timothy fields for about a month. A more intensive flight occurs on warm sunny days for 2 -3 weeks. In Central Sweden this period takes place in the first half of May in early springs, and during the end of May and the beginning of June in late springs. The females are egg-mature about eight days after emergence. The eggs are laid in the same way by both species and generally on the upper side of the leaf next to the ligule. They are laid singly and parallel to the veins of the leaf. The development of the egg and larva is the same in the two species. The egg hatches after about five days and the larva needs about fifteen days to reach its full size. The larvae pupate in the ground. In one experiment 98 % of the larvae pupated after three days. The pupation takes place near the surface, most of the pupae are to be found in an upper layer of the soil (0—2.5 cm.).

In international literature information may be found on attacks by Timothy flies on rye, barley, wheat and on some other grasses besides Timothy. Some of these reports are not reliable, since the injury has often been classified by the symptoms only, not by determining the pest itself. In Sweden, only Timothy grass has been proved to be a host plant for *armillatum* and *flavipes* Fall. In tests where several eggs were laid on Timothy no oviposition occurred on rye, wheat or couch-grass (*Agropyron repens*).

During the investigations the following parasite wasps have been reared from *A. armillatum* Zett. and *flavipes* Fall.:

Chalcidoidea: *Stictomischus gibbus* Walk., *Seladerma laetum* Walk. and *Stenomalina* sp.

Braconidae: *Chasmodon apterus* Nees, *Mesocrina venatrix* Marsh., *Rhizarcha areolaris* Nees, *Dacnusa cincta* Hal. and *Ectilis* (*Dacnusa*) *semirugosa* Hal.
Cynipoidea: *Eutrias tritoma* Thoms.
Ichneumonidae: 1 species belonging to subfamily *Ophioninae*.

Among these *S. laetum* and *E. semirugosa* have been reared in several specimens from different places. They are therefore to be considered as important parasites of the Timothy grass flies in Sweden. They emerge from puparia of *Amaurosoma* somewhat later than *A. armillatum* and *flavipes*. *E. semirugosa* emerged a little earlier than *S. laetum*. After spraying with DDT against Timothy flies, the risk of high mortality among the parasite wasps is particularly great among *E. semirugosa* *S. laetum* on the other hand has greater chances of escaping the toxicity of a DDT-spraying, since the residual effect of the material will have been greatly reduced by the time this wasp is flying. In order not to damage a wasp population unnecessarily, chemical control (this is particularly applicable to DDT) should not be applied unless there are very good reasons for it, such as in years with mass occurrence of Timothy grass flies.

V. After emerging, the larva of *Amaurosoma* moves to the young ear inside the sheath and feeds upon the flowering parts. The axis of the ear is not damaged, nor the stem itself. At the heading stage the larva is mature. Generally, there is only one larva per attacked ear. The seeds are destroyed to about 50 % in damaged ears.

Serious attacks of *Amaurosoma* have occurred in Sweden from time to time both in mineral soils and in organic soils. The age of the Timothy fields is not correlated to the degree of infestation. Severe attacks can occur in one and two year old fields as well as in older Timothy grass fields.

VI. The writer's experiments have been almost exclusively directed towards chemical control of the adult flies before and during the oviposition. Six field experiments were carried out during the years 1951—56. The time of application was determined every year on the basis of the results of nettings. Among chemicals, was chiefly DDT tested, also as a mixture with the herbicide MCPA. Parathion was tested in two experiments and BHC in one.

The application was made by means of a hand-dusting method in test 1, and in the other tests with tractor-driven sprayers and with airplane dusting. The plots in test 1 were 1 200 m^2 and in the other tests from 0.5—3 hectare. The effect of the treatments was observed through regular nettings and by an estimate of the degree of infestation in the Timothy grass. In test 5, the number of eggs was also counted on 50 plants per plot. A summary of the control experiments is given in table 12. DDT-spraying was the most effective control. The dosage of 600—800 g actual

ingredient per hectare gave good commercial control. The amount of spray liquid was varied from 400 to 185 litres per hectare. In two tests DDT was mixed with MCPA without the effect being reduced. Airplane dusting with DDT (1 000 g actual toxicant per hectare) was less effective than spraying with a smaller dosage (600—800 g).

Spraying with Parathion (175—180 g actual toxicant per hectare) was inferior to spraying with DDT. DDT spraying on Timothy grass in favourable weather leaves a visible residual effect lasting approximately a fortnight. Parathion is effective only for about six days.

BHC was applied in one test without any result being noted.

Sammanfattning

Undersökningar över timotejflugornas (Amaurosoma armillatum Zett och A. flavipes Fall.) biologi och bekämpning.

(Numrering enligt kapitelindelning.)

I. Bland flugor, som betecknas timotejflugor, nämns i litteraturen *Amaurosoma armillatum* Zett. och *A. flavipes* Fall. från ett flertal länder i Europa samt en närstående art *Trichopalpus* (*Chaetosa*) *punctipes* Meig. från bl. a. Frankrike.

Synonymer:

Amaurosoma armillatum Zett.
Cordylura armillata Zett.
Cleigastra armillata Zett. (Schin.)
Cnemopogon obscura var. 2 (*armillata*) Pandellé.

Amaurosoma flavipes Fall.
Cordylura flavipes Fall.
Cordylura frontalis Macq.
Cleigastra flavipes Schin.
Cnemopogon flavipes var. 1 Pandellé.

Trichopalpus punctipes Meig.
Chaetosa punctipes Mall.
Cleigastra punctipes Macq.
Cleigastra flavipes Meig.

Att larverna av *A. armillatum* Zett. lever som skadedjur i timotejax klargjordes av Lampa (1893). Äldre uppgifter rörande biologin hos *A. flavipes* Fall. är ofta osäkra emedan *flavipes* Fall. och *flavipes Meig.* ej alltid åtskilts. Sålunda beskriver Lindeman (1887) biologin hos en timotejfluga, som han uppfattat som *Cleigastra flavipes* Meig. Av hans beskrivning över flugorna framgår emellertid klart att det ej är fråga om *flavipes* Meig. (=*Trichopalpus punctipes* Meig.) utan om en annan art, troligen *A. armillatum*. I litteraturen har författaren ej påträffat några säkra belägg för att larver av *T. punctipes* Meig. lever i timotejax.

För *A. flavipes* Fall. är timotej den naturliga värdväxten. I en del systematisk litteratur (Séguy 1934, Sack 1937) uppges även *Euphorbia* som värdväxt för arten, troligen beroende på missuppfattning av en äldre litteraturuppgift av Pandellé (1898), som uppger att han fångat *A. flavipes* Fall. på *Euphorbia* vid Tarbes i södra Frankrike.

Sammanfattningsvis kan sägas, att hitintills har inom familjen *Cordyluridae* med säkerhet endast *A. flavipes* Fall. och *armillatum* kläckts ur fluglarver insamlade från skadade timotejax.

II. Imagines av de två arterna liksom ägg, larv och puppa (puparium)

beskrivs. Beträffande ägg, larv och puppa har några säkra morfologiska skillnader mellan de två arterna ej påvisats.

III. Timotejflugorna *armillatum* och *flavipes* Fall. är främst kända från Europa. I Sverige förekommer båda arterna över hela landet (fig. 6).

Genom kläckningar av larver insamlade från timotej på olika biotoper samt genom håvningar i timotej på fastmarksjordar samt på myrjordar har påvisats att *armillatum* i regel är den vanligaste arten på fastmarksjordar och *flavipes* Fall. på myrjordar och liknande fuktigare lokaler (tabell 1).

IV. För bestämning av flugornas kläckningsperiod insamlades timotejflugelarver ute i fält vid timotejens axgång. Larverna lades till kläckning utomhus under naturliga förhållanden. Kläckningsperioden under sex år (under tiden 1950—56) framgår av fig. 8—10. Som syns sker kläckningen under en relativt kort period i maj månad. Inom en 10-dagarsperiod har sålunda de flesta av flugorna framkommit. Båda arterna kläcks samtidigt och hanarna dominerar i början av kläckningsperioden och honorna i slutet av densamma (fig. 9—10).

Hanar och honor förekommer i ungefär samma antal. Vid kläckningar har frekvensen honor av *armillatum* varit 50,9 % (83 st) och av *flavipes* 57,2 % (282 st). Vid håvningar har av *armillatum* 49,6 % (482 st) varit honor och av *flavipes* 56,2 % (3 630 st). Se tabell 2 och 3.

Timotejflugorna flyger ute i timotejvallarna i ungefär en månads tid. En intensivare svärmning pågår soliga, varma dagar under 2—3 veckor. I mellersta Sverige infaller denna tid i förra delen av maj under tidiga år och under senare delen av maj—början av juni under sena somrar. Honorna innehåller läggfärdiga ägg först ca 8 dagar efter kläckningen.

Äggen läggs ett och ett och på samma sätt hos de två arterna, i regel på bladets översida helt nära stammen. Äggets längdriktning sammanfaller med bladets. Ägg- och larvutveckling är densamma hos de två arterna. Ägget kläcks efter ca 5 dygn och larven behöver omkring 15—20 dygn för sin utveckling. De fullbildade larverna förpuppar sig i jorden. I försök hade 98 % av larverna förpuppats redan inom 3 dygn sedan de placerats på fuktad sand. Förpuppningen sker nära ytan, de flesta puparier finner man i ett översta jordskikt på 0—2,5 cm.

I utländska litteraturuppgifter uppges att timotejflugorna även kan angripa råg, korn, vete samt en del andra gräs förutom timotej. Många av dessa uppgifter torde vara osäkra emedan man i regel endast bedömt skadan efter symtom, men däremot ej kläckt skadedjuret ur angripna plantor. I Sverige har endast timotej påvisats som värdväxt för *armillatum* och *flavipes* Fall. I försök där timotej äggbelades rikligt lade flugorna inga ägg på råg, vete eller kvickrot (se även kap. I).

Vid undersökningarna har följande parasitsteklar kläckts ur *A. armillatum* Zett. och *flavipes* Fall.:

Chalcidoidea: *Stictomischus gibbus* Walk., *Seladerma laetum* Walk. och *Stenomalina* sp.
Braconidae: *Chasmodon apterus* Nees, *Mesocrina venatrix* Marsh., *Rhizarcha areolaris* Nees, *Dacnusa cincta* Hal. och *Ectilis* (*Dacnusa*) *semirugosa* Hal.
Cynipoidea: *Eutrias tritoma* Thoms.
Ichneumonidae: En art, tillhörande underfamiljen *Ophioninae*, ej närmare bestämd.

Av dessa har *S. laetum* och *E. semirugosa* kläckts i stort antal från flera lokaler. De kan därför betraktas som de viktigaste parasiterna på timotejflugorna i Sverige. De sistnämnda steklarna kläcks ur timotejflugepuparier något senare än *A. armillatum* och *flavipes*. *E. semirugosa* framkommer något tidigare än *S. laetum*. Efter besprutning med DDT mot timotejflugorna föreligger stor risk för hög dödlighet bland parasitsteklarna, särskilt hos *E. semirugosa*. Den något senare flygande *S. laetum* har däremot bättre möjlighet att undgå giftverkan av en DDT-besprutning, riktad mot timotejflugorna, på grund av att preparatets efterverkan avtagit starkt till den tid då dessa steklar flyger.

För att ej onödigtvis skada populationen av parasitsteklar bör kemisk bekämpning (särskilt gäller detta för DDT) ej sättas in annat än då starka skäl för sådan bekämpning verkligen föreligger såsom under år med massförekomst av timotejflugor.

V. Den nykläckta larven uppsöker axanlaget inuti bladslidan och livnär sig av blomdelarna. Axspindeln skadas ej och ej heller själva strået. Vid axgången är larverna fullvuxna. I regel finns blott en larv per angripet ax och detta skadas så att ca 50 % av fröet går förlorat.

Allvarliga härjningar av timotejflugor har förekommit i Sverige tid efter annan (tabell 7) och såväl på fastmarksjordar som på myrjordar m. m. Timotejvallarnas ålder är ej avgörande för angreppets intensitet. Svåra angrepp kan förekomma på såväl 1- och 2-årsvallar som i gamla vallar.

VI. Författarens bekämpningsförsök har så gott som helt inriktats på bekämpning med kemiska medel av de fullbildade flugorna före och under äggläggningen. Sex fältförsök utförda under åren 1951—56 beskrivs. Tidpunkten för den kemiska behandlingen har varje år bedömts bl. a. med ledning av frekvenshåvningar. Av kemiska preparat har i första hand DDT prövats, även i förening med ogräsmedel (4K2M). Vidare har paration prövats i två försök och hexaklor (BHC) i ett försök.

Behandlingen utfördes i försök 1 med handdriven puderspridare, i de övriga försöken med traktordragen spruta samt med flygbepudring. De olika försöksytorna i försök 1 var 1 200 m^2, i de övriga försöken mellan 0,5—3 ha per försöksled. Effekten kontrollerades dels medelst regelbundna frekvenshåvningar, dels genom att avräkna angreppet i axen efter ax-

gången. I ett försök beräknades dessutom antalet lagda ägg på timotejen vid en viss tidpunkt. En sammanfattning av bekämpningsförsöken framgår av tabell 12.

I försöken har bästa resultat nåtts genom besprutning med DDT. Doseringen 600—800 g verksam substans per ha (d. v. s. 3—4 liter av en 20 % DDT-emulsion) har medfört fullt tillfredsställande effekt. Vätskemängden tycks i detta fall vara av mindre betydelse, den har i försöken varierat mellan 400—185 liter per ha utan att detta tycks ha påverkat det praktiska resultatet. I två försök har DDT-preparat blandats med ogräsmedel av 4K2M-typ utan att effekten mot timotejflugorna försämrats. Flygbepudring med DDT (1 000 g verksam substans per ha) har medfört sämre resultat än besprutning med lägre dos (600—800 g).

I besprutningsförsök med paration (175—180 g verksam substans per ha) har osäkrare resultat nåtts än med DDT. Långtidsverkan av en DDT-besprutning i timotej har vid gynnsam väderlek tydligt påvisats under ca 14 dagar. För paration har effekten försvunnit efter 7 dagar.

Hexaklor (BHC) har prövats i ett försök utan verkan.

References

Balachowsky, A. and Mesnil, L. 1935. Les Insectes nuisibles aux Plantes cultivées. — Paris.

Barnes, H. F. 1935. Notes on the Timothy Grass Flies (*Amaurosoma* spp.). — Ann. appl. Biol. 22: 2.

Becker, T. 1894. Dipterologische Studien. I. Scatomyzidae. — Berl. Ent. Zeitschr. 39: 1.

Borg, Å. 1953. Vitaxighet på råg 1952. — Växtskyddsnotiser 17: 1.

———, 1955. Timotejflugorna och deras bekämpning. — Svensk Frötidn. 24: 4.

Bremer, H. and Kaufmann, O. 1931. Die Rübenfliege *Pegomyia hyoscyami* Pz. — Monogr. zum Pflanzensch. 7, Berlin—Dahlem.

Delucchi, V. 1955. Contribution à l'étude des Lamprotatinae (Chalcid., Pteromalidae). — Lunds Univ. Årsskrift N. F. 50: 20.

Ericsson, G. and Skoog, H. 1955. Vallfröodlingsförsök vid Statens försöksgård Offer 1934—1954. — Stat. Jordbruksförsök Meddel. 53.

Fallén, C. F. 1819. Diptera Sveciae Scatomyzides. — Lundae.

Hackman, W. 1956. The Scatophagidae (Dipt.) of Eastern Fennoscandia. — Soc. pro Fauna et Flora Fenn., Fauna Fenn. II.

Johansson, E. 1938. Något om timotejflugan och dess härjningar. — Växtskyddsnotiser 2: 4.

Karpova, A. I. 1930. Beitrag zur Kenntnis von *Amaurosoma flavipes* Fall. und *A. armillatum* Zett. — Rep. on appl. ent. 4: 2.

King, L. A. and Meikle, A. A. 1933. A Fly pest of Timothy Grass. — Nature 81: 3319.

King, L. A., Meikle, A. A. and Broadfoot, A. 1935. Observations on the Timothy Grass Fly (*Amaurosoma armillatum* Zett.). — Ann. appl. Biol. 22: 2.

Lampa, S. 1892—1901. Berättelse till lantbruksstyrelsen 1891—1900. — Upps. i prakt. ent. 2—11. (Ent. Tidskr. 13—22).

Lind, J., Rostrup, S. and Ravn, F. K. 1914—1919. Oversigt over Landbrugsplanternes Sygdomme. — Tidskr. for Planteavl 21—26.

Lindeman, K. 1887. Entomologische Beiträge. 3. Über Lebensweise und Verwandlungen der Cleigastra flavipes Mg. — Bull. Soc. Imp. Nat. Moscou N. S. 1.

Lindfors, T. and Tunblad, B. 1947. Sjukdomar och skadedjur på våra lantbruksväxter. — Stockholm.

Lundblad, O. 1933. Kålflugorna. — Statens växtskyddsanstalt Meddel. 3.

Meigen, J. W. 1826. Systematische Beschreibung der bekannten europäischen zweiflügeligen Insekten, 5. — Aachen und Hamm.

Mühle, E. 1953. Die Krankheiten und Schädlinge der zur Samengewinnung angebauten Futtergräser. — Leipzig.

Newton, H. C. F. 1932. Report on insect pests of the Rothamsted farm 1930—31. — Rep. 1931, Roth. Exp. Stn.

Nowicki, M. 1874. Beobachtungen über der Landwirthschaft schädliche Thiere in Galizien im Jahre 1873. — Verh. zool.-bot. Gesellsch. in Wien 24.

Pandellé, L. 1898—1902. Études sur les Muscides de France. — Revue d'Entomologie.

Reuter, E. 1900. Über die Weissährigkeit der Wiesengräser in Finland. — Acta soc. pro Fauna et Flora Fennica 19: 1.

Ringdahl, O. 1952. Catalogus Insectorum Sueciae XI. Diptera Cyclorrapha: Muscaria Schizometopa. — Opusc. Ent. 17: 3.

Rostrup, S. 1940. Vort Landbrugs Skadedyr (5:te revid. uppl. ved P. Bovien og M. Thomsen). — København.

Sack, P. 1937. Die Fliegen der Palaearktischen Region (E. Lindner) 62. Cordyluridae. — Stuttgart.

Schiner, J. R. 1864. Fauna Austriaca. II. Die Fliegen (Diptera). — Wien.

Schöyen, T. H. 1914—1930. Beretning om Skadeinsekter og Plantesygdomme. — Oslo (Kristiania).

Schöyen, W. M. 1892—1913. Beretning om Skadeinsekter og Plantesygdomme. — Oslo (Kristiania).

Séguy, E. 1934. Faune de France, 28. Diptères (Brachycères). Muscidae Acalyptera et Scatophagidae. — Paris.

Sorauer, P. 1914. Altes und Neues über die mekanischen Frostbeschädigungen. — Z. f. Pflanzenkrankh. 24.

Stapel, C. 1946. Landbrugsplanternes Sygdomme og Skadedyr. — København.

Taschenberg, E. L. 1880. Praktische Insekten-Kunde IV. — Bremen.

Tullgren, A. 1929. Kulturväxterna och djurvärlden. — Stockholm.

Wahl, B. 1943. Über Timotheegrasfliegen. — Arb. physiol. angew. Ent. Berlin-Dahlem 10: 2—3.

Wahlgren, E. 1917. Svensk Insektfauna 11. Diptera. Cyclorapha. Andra gruppen: Schizophora. — Uppsala.

Yaroslavtzev, G. 1928. Insect Pests in 1927. Zapad. Obl. S. — Kh. Op. Stanz. 29. — *Ref.* Rev. Appl. Ent. 19 (1931): p. 135.

Zetterstedt, J. W. 1846. Diptera Scandinaviae disposita et descripta, V. — Lundae.

Znamenskaya, M. K. 1941. Pests of Cereal and Forage Crops in the Khibins (Murmansk District). — Bull. Plant Prot. 1. — *Ref.* Rev. Appl. Ent. 30 (1942) p. 376.